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ECONOMIC OUTLOOK FOR AGRICULTURE IN THE UNITED STATES*

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Of the many causes to which the agricultural depression is attributed, at least three must be given consideration.

German economists see a large population with low buying power and attribute the depression to the inability of Germany to buy. (*1*)

Americans find difficulty in selling at satisfactory prices and attribute the depression to over-production.

Most of the English economists (*2*) attribute the trouble to a decline in the whole price level for commodities because the low production of gold and high demand for it are causing gold rapidly to approach its pre-war value. It is interesting to note that Professor Allyn A. Young (*3*) who went from Harvard to the University of London wrote a complete endorsement of this explanation after he had been in England a few years.

If the trouble is monetary, it is a much more complicated and far-reaching problem than mere over-production. I will ask you to bear with me while I present a little of the evidence on the subject, and particularly ask you to compare the proposed remedies and see in what respects they differ and in what respects they agree.

Why did wholesale commodity prices rise to over 200 in 1920? Why did they drop from this level to the level of about 140 to 150 which held for nine years? Why have they now dropped to 120? Can reduced production bring back the 150 price level, or are we on a permanently lower level? Since 1917, I have been presenting my answers to these questions. (*4*)

There is never a time when there is not a surplus of something. Nor is there a time when there is not a shortage of something. This year, there is a surplus of wheat and a shortage of corn, potatoes, and hay. We have a surplus of sheep and cattle, and a low production of hogs. But these surpluses and shortages change from year to year. The problem which I am discussing is as to whether there is general over-production in agriculture and in industry as a whole.

THREE PERIODS OF DEFLATION SIMILAR

In the period of deflation following the Napoleonic Wars, prices in England declined from an index of 211 in 1814 to 128 in 1824. Prices declined nearly one-half in ten years.

In the United States, following the War of 1812, prices declined from an index of 250 in 1814 to 115 in 1824. Prices declined more than one-half.

* This paper, presented by Dr. Warren to the American Farm Bureau Federation at Boston, Mass., December, 1930, contains substantially the same material used in his lecture at the 10th Annual Convention of the C.S.T.A., Wolfville, Nova Scotia, June 25, 1930, and has the advantage of the inclusion of additional figures made available recently.

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In the similar period of financial deflation following the Civil War, prices fell from an index of 209 in July 1864 to 114 in July 1874. Again, prices declined almost one-half in ten years.

In May 1920, wholesale prices of all commodities averaged 244 when the five years before the War is called 100. In October this year, the same index number stood at 121. Once more, prices have declined one-half in ten years.

In each case, the popular explanation was over-production. Goods are difficult to sell, and since large supply is one of the common reasons for inability to sell, the tendency is to interpret any difficulty in selling as due to over-supply. Probably the majority of American economists attribute the depression to supply and demand. But English economists generally agree with my statement that the trouble is primarily monetary.

Cotton Acreages Increase

If the correct diagnosis is to be made, cotton must be separated from food products. It is an industrial crop which reacts very differently from the manner in which food crops react. In the seven years, 1923 to 1929, cotton prices paid to farmers averaged 65 per cent higher than for the five years before the War, whereas, prices paid to farmers for food products averaged only 43 per cent above pre-war. This cotton price of 65 per cent above pre-war was much above the average of all commodities which was 44 per cent above pre-war. Certainly, this does not indicate that there was over-production of cotton in these seven years, but the very high prices for cotton resulted in a great expansion in the cotton acreage. The Department of Agriculture estimated the cotton acreage for 1919 as 33,566,000, and for 1929, as 45,793,000, or an increase of 36 per cent in ten years. Rarely, has such a phenomenal increase in a major crop occurred. It may be that there is over-production, and, of course low demand due to the business depression is very important. In the same period, sheep increased 15 per cent. But the position of the food and feed crops is entirely different.

Food Production

The acres of food and feed crops in the United States increased 14 per cent from 1909 to 1919.* In this period, population increased 21 per cent. There was no agricultural depression at any time during this period.

In 1919, the acreage of thirty-eight food and feed crops was 319,037,000, and in 1929, the acreage of the same crops was 314,633,000, a decrease of 1 per cent. In this period, population increased 16 per cent.†

It is rather surprising that in one period, production of food and feed crops could increase two-thirds as fast as population without getting into trouble, but that in the second period, food and feed crops could decrease 1 per cent and population increase 16 per cent, and still have a disastrous depression due to over-production.

*Fourteenth Census of the United States, Vol. V, pp. 700-701. Minor vegetables are omitted as the figures for the two periods were not comparable.

†The 1929 acreages are for 38 crops from the United States Department of Agriculture Yearbook, 1930, p. 970, but omiting cotton, flaxseed, cloverseed, tobacco, broomcorn, hops, cane syrup, and maple trees. If all crops except cotton and maple trees are included, there is a decrease of 1 per cent. If cotton and all other crops are included, the increase from 1919 to 1929 is 3 per cent. Acreages for 1919 are from the United States Department of Agriculture Yearbook, 1921, pp. 770-771, except for crops not given on these pages which are taken from the 1920 Census, Vol. V, pp. 701, 791, and 820. The Census report includes only vegetables sold, hence the decrease is a little more than the figures here used.

The substitution of tractors for horses which has occurred in this period has reduced demand somewhat. This substitution has released about 6 per cent of the total crop area or about 8 per cent of the area in crops other than cotton.‡ If we make allowance for this change in demand, we could say that the combined effect is equivalent to an increase of 7 per cent in food and feed crops, while population increased 16 per cent.

Crop yields per acre for food and feed crops are about the same as they were ten years ago. Yields per acre had been rising before the War, but this rise appears to have been checked. Wheat and oat yields in the last ten years have been a little below the previous ten-year average. Barley, corn, potatoes, and hay have increased.

This year, owing to the drought, yields of the 17 principal crops, (including cotton) are estimated by the Department of Agriculture as 5 per cent below the ten-year average. Production of these crops per capita is 13 per cent below the ten-year average.

In the face of these facts, we are expected to believe that general over-production is the cause of a decline in prices paid to farmers for food products from an index of 156 in September last year to 120 in October this year.

The Census shows a decrease of 2 per cent in the number of farms in the United States from 1920 to 1930. The change in acreage is not yet tabulated.

TABLE 1.—*Yields per acre as estimated by the Department of Agriculture.*

	Ten Years 1910-1919	Ten Years 1920-1929	1930
Wheat, bushels	14.6	14.2	14.2
Corn	26.2	28.0	20.6
Oats	32.1	31.1	33.7
Barley	25.0	25.2	25.7
Potatoes	95.4	110.5	105.8
Hay, tame, tons	1.44	1.56	1.41

Let us go back to 1920. In that year, the stores hoarded by Governments began to be thrown on the markets, production was high, and the horse, beef and hog cycles were, by accident, coincidently at a peak. Three cycles of different lengths will inevitably reach a simultaneous peak at rare intervals. This would have occurred had there been no war. Over-production was an important factor in the agricultural situation in 1921, but even then, I believe that more than half of the depression was due to monetary causes.

In recent years, we have had surpluses and shortages of almost every food crop, but the depression goes on.

Production of All Commodities Not Excessive

The physical volume of production in the United States, that is, the quantities of products when measured in tons, pounds, and bushels, has been rising steadily over a series of years. This includes all products, not merely agriculture. Figures furnished by the Harvard Economic Service show that in the fifteen years from 1900 to 1914, the physical volume of production

‡Cavert, W. L.: The Horse Situation, Farm Economics, No. 61, p. 1175, October, 1929.

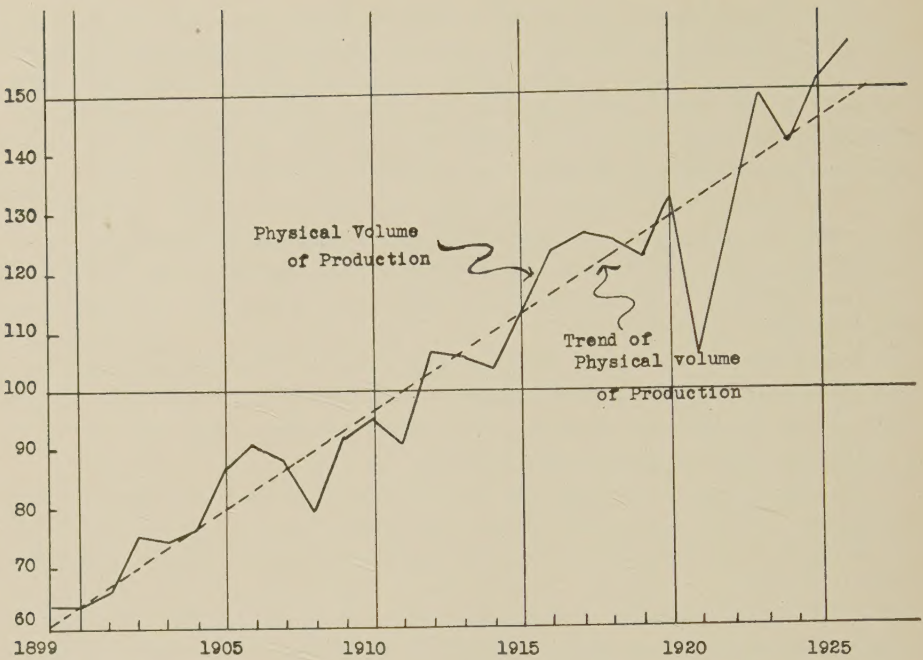

Figure 1. Physical volume of production—Agriculture, Mining, and Manufacturing in the United States, 1910-1914=100.

Over a series of years, production increases at a fairly uniform rate. It was very low in 1921, and is very low this year.

increased about 61 per cent. In this period, prices rose steadily. In the following thirteen years, production increased 53 per cent or at about the same rate as formerly. There was a decided drop in production in 1921, and now there is again a decided drop in production, but there has been no phenomenal increase in production of all industry combined. Increases have gone on at a fairly uniform rate. There can be a sudden and violent drop in production below the trend line such as occurred in 1921, but not a sudden and violent production far above the trend line can occur.

Prices of Food and Other Commodities

Comparative prices give further evidence of the question of supply. In popular opinion, low prices for food products indicate that something is wrong with the supply of food or the demand for it. But prices are a ratio of the value of gold to the value of another commodity. If John weighs twice as much as James, it does not follow that John is necessarily large, or James is necessarily small. If 3 pounds of butterfat exchange for only 23.22 grains of gold, it does not necessarily follow that butter is abundant. Gold may be scarce. There is no way of arriving at a judgment that is worth a farthing unless some other comparison is made. If butter has its usual exchange value when compared with the average of 550 other commodities, and if wheat and these 550 commodities have a low exchange value for gold, the logical conclusion is that gold is becoming more valuable.

What are the facts on the exchange values between food products and many kinds of commodities, not merely the one sacred commodity, gold?

TABLE 2.—*Index numbers of the physical volume of production, 1899 to 1926* 1910-1914 = 100*

Year	Agriculture	Mining	Manufacturing	Total
1899	79	45	60	64
1900	80	48	60	64
1901	71	52	67	66
1902	90	56	73	76
1903	83	61	74	75
1904	92	62	73	77
1905	94	74	85	86
1906	99	77	90	91
1907	89	85	90	89
1908	94	70	75	80
1909	94	86	92	92
1910	97	95	95	95
1911	91	94	91	91
1912	109	100	105	106
1913	96	108	110	105
1914	109	102	101	103
1915	114	109	113	112
1916	100	122	134	123
1917	106	131	135	126
1918	107	131	133	125
1919	109	117	130	122
1920	119	133	138	131
1921	98	106	107	104
1922	110	115	141	129
1923	110	159	167	149
1924	108	147	154	140
1925	111	151	173	152
1926	113	164	179	158
1927	113			
1928	118			
1929	112			

*Maxwell, W. F. : Physical Volume of Production in the United States for 1926. The Review of Economic Statistics, Vol. IX, No. 3, page 149, January, 1927.

For the four years, 1921 to 1924, wholesale prices of the 550 commodities reported by the Bureau of Labor Statistics averaged 144 when pre-war is considered as 100, (table 3). Prices paid to farmers for food averaged only 125. The prices which farmers received were low compared with other wholesale prices. In this period, there was an over-production of food products relative to demand. This was a very important factor in the agricultural depression, but I do not believe that it was the major factor.

In the five years, 1925 to 1929, wholesale prices of the 550 commodities again averaged 144, whereas prices paid to farmers for food averaged 150. In July, this year, after the drastic recent decline in prices, and before the effects of the drought, wholesale prices of the 550 commodities averaged 123, and farm prices of food, 124. If the supply of food products is high or the demand low, we must conclude that other commodities are in the same situation. To assume that all commodities are over-produced and that only gold is stable, is like bringing the mountain to Mohammed.

In a period of financial deflation, producers' prices are always low compared with consumers' prices. Retail prices of food in the United States must, therefore, be compared with retail prices of other commodities, if we are to determine whether food is high or low. In the four years, 1921 to 1924, the retail price of food in the United States averaged 155, when

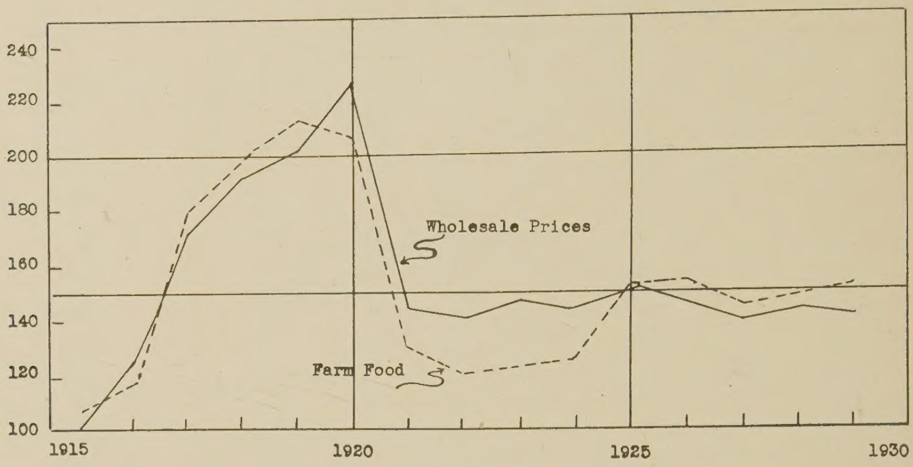

Figure 2. Prices paid to farmers for food and wholesale prices of all commodities in the United States, 1910-1914=100.

Wholesale prices of food at the farm were higher than other wholesale prices from 1917 to 1919. From 1920 to 1924, food was below other wholesale prices. Apparently there was an over-supply of food. Since 1924, farm prices of food have been slightly higher than other wholesale prices. Apparently there is no longer a surplus of food.

Table 3.—*Index numbers of prices in the United States*, 1910-1914 = 100.*

Year	Wholesale prices of all commodities	Prices paid to farmers for food	Prices of food at retail	Cost of living	Cost of distri-buting food	Prices paid to farmers for cotton
1913	102	100	103	104	104	97
1914	99	105	106	104	105	85
1915	102	106	107	102	105	72
1916	125	117	117	112	110	109
1917	172	181	156	131	129	173
1918	192	200	180	160	159	238
1919	202	213	194	182	174	239
1920	226	207	207	212	202	259
1921	143	130	163	180	190	100
1922	141	121	150	168	175	152
1923	147	124	154	172	177	215
1924	143	126	153	170	180	216
1925	151	152	169	175	185	179
1926	146	154	174	176	192	122
1927	139	145	169	173	190	128
1928	143	149	170	171	190	150
1929	141	151	174	172	199	143
1930 (Oct.)	121	120	158	164	197	76

* Farm Economics, No. 68, pp. 1417 and 1420, November, 1930.

pre-war is considered as 100. The cost of living averaged 173. This agrees with wholesale prices in indicating that food was relatively abundant.

In the five years, 1925 to 1929, food at retail averaged 171. The cost of living again averaged 173. Apparently, food was little more abundant than other things.

In 1929, food averaged 174 and the cost of living averaged 172.

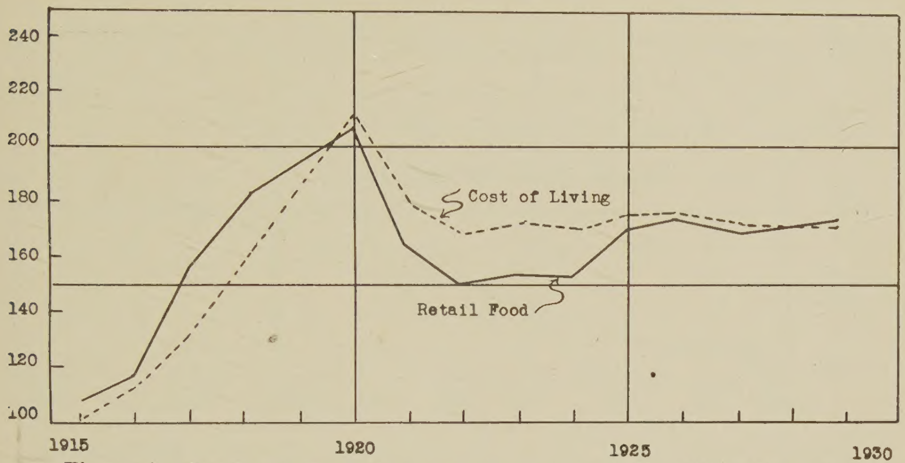

Figure 3. Retail prices of food and the cost of living, 1910-1914=100. From 1921 to 1924, food was cheap. Since then, it has been at about the same price level as other items in the cost of living.

Similar comparisons hold in England. Enfield states that in Great Britain, in 1929, agricultural prices (which in England are primarily food prices) were 44 per cent above pre-war. The average for all commodities was 35 per cent above pre-war.

Purchasing Power of Wages Rises as Efficiency Increases

When the whole price structure falls, decided mal-adjustments in the price structure occur. Before we can understand these, it is necessary to give attention to the difference between wages and commodity prices.

If wholesale prices remain stable, wages will rise at approximately the same rate as the increase in physical volume of production per capita in the country.

In the thirty-five years before the War the physical volume of production per capita corrected for imports and exports, increased about 62 per cent. In this same period, the purchasing power of wages increased 57 per cent.*

Figure 4 shows the trend in the purchasing power of wages since 1840. Between 1860 and 1910, the quantity of commodities at wholesale prices that an hour's labor would buy more than doubled.

While the long-time tendency of wages is to rise as production rises, the short-time changes are strikingly affected by financial inflation and deflation. When prices rose rapidly during the Civil War period, wages rose less rapidly than prices. Therefore, the purchasing power of wages declined. In the period of rising value of gold and consequent fall in prices, which culminated in 1896, the purchasing power of wages rose with unusual rapidity. These experiences have been repeated since 1914. When prices rose rapidly in the War period, wages rose slowly, and the purchasing power of wages declined. When prices declined in 1920, wages rose and the purchasing power of the wages rose with great rapidity.

* The percentage of population gainfully employed, hours of labor per day, and a number of other factors must be considered, if great refinement in these figures is desired. The data here given are sufficiently accurate for the purposes for which they are used. The buying power of labor is determined by dividing United States Bureau of Labor Statistics union wage rates by their index numbers of wholesale prices of all commodities.

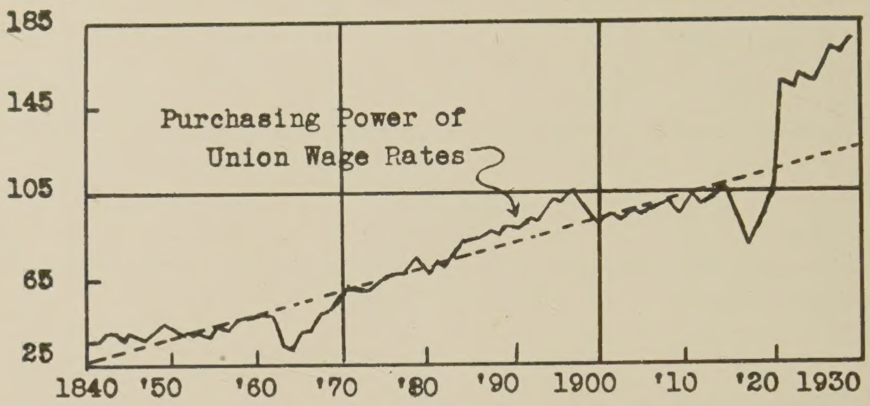

Figure 4. Purchasing power of union wage rates, 1840-1929. 1910-1914=100.

The curved line shows the purchasing power of wages year by year. The straight line shows the long-time trend of the quantity of commodities at wholesale prices that wages would buy. The buying power of wages more than doubled from 1860-1910.

TABLE 4.—*Index numbers of wholesale prices and wages.*

England Napoleonic War Period 1790 = 100			United States Civil War Period 1856-60 = 100			United States World War Period 1910-1914 = 100		
Year	Wholesale prices (a)	Wages (b)	Year	Wholesale prices (c)	Wages (d)	Year	Wholesale prices (e)	Wages(e)
1790	100	100	1860	94	99	1914	99	101
1795	134	114	1861	92	102	1915	102	104
1800	160	129	1862	109	105	1916	125	116
1805	155	144	1863	152	112	1917	172	132
1810	188	169	1864	193	128	1918	192	164
1816	125	160	1865	172	148	1919	202	190
1820	121	151	1866	175	156	1920	226	227
1824	106	156	1867	157	161	1921	143	207
1831	92	143	1868	153	166	1922	141	202
1840	102	139	1869	141	168	1923	147	220
1845	87	138	1870	130	171	1924	143	223
1850	77	142	1871	129	173	1925	151	228
1855	101	161	1872	131	176	1926	146	234
1860	99	161	1873	130	176	1927	139	236
			1874	125	171	1928	143	237
			1875	119	171	1929	141	242
			1876	108	163	1930 Oct.	121	226
			1877	100	156			
			1878	92	153			
			1879	89	151			
			1880	99	153			

(a) Warren, G. F. and Pearson, F. A. : The Agricultural Situation, p. 263, 1924.

(b) Wood, G. H. : The Course of Average Wages Between 1790 and 1860, The Economic Journal, Vol. IX, No. 36, p. 591, December, 1899.

(c) Warren, G. F. and Pearson, F. A. : Farm Economics, No. 45, p. 698, June, 1927.

(d) Index Numbers of Wages per Hour, 1840-1926. Monthly Labor Review, Vol. XXVI, No. 2, p. 332, February, 1928.

(e)) Farm Economics, No. 68, p. 1417, November, 1930.

During Inflation and Deflation Wages Lag Behind Prices

A rapid rise in prices makes it possible to hire laborers with the proceeds of an unusually small portion of the product which they make, hence there is an extremely active demand for labor. Declining prices make it necessary to pay laborers an unusually large proportion of the products, hence there are frequent periods of unemployment, but those who are employed have a high buying power.

Whenever prices rise rapidly, wages rise less rapidly. Whenever prices fall, wages fall less rapidly, or may not decline at all. In England, during the Napoleonic Wars, wholesale prices rose to an index of 188 in 1810 when 1790 is considered at 100. Wages rose to only 169. Twenty-one years later, prices had fallen to an index of 92, but wages were 143. Prices were cut in half, but wages declined only 15 per cent.

Similarly, in the Civil War period, in the United States, prices declined by more than one-half from 1864 to 1879, but wages were actually higher in 1869 than they were in 1864. The peak in wages came in 1873. From this peak, wages declined only 14 per cent.

In the World War period, prices reached a peak in 1920, but wages did not reach a peak until nine years later just as they did following the Civil War. Prices have declined nearly one-half, but there has been little decline in wages.

It is to be expected that the reaction from cheap gold will make wholesale prices drop below the pre-war level at some time in the next five to ten years. If the Civil War and Napoleonic War experiences are repeated, wages will decline slightly as they did in those periods, but no great decline is to be expected.

If there had been no war, and wholesale prices had been stationary, the pre-war trend in wages probably would have caused a rise of about 25 to 30 per cent in the sixteen years since the War started. Since prices in 1929 were 41 per cent above pre-war, wages at about 80 per cent above pre-war would have shown their normal increase. The great decline in commodity prices in the past year would lower this normal figure to about 50 per cent above pre-war.

When the purchasing power of wages rises with unusual rapidity, as it does when prices drop, there is a great increase in the efficiency with which labor is used, so that to some extent, high wages make high wages possible. But many business concerns are unable to increase the efficiency of labor quickly enough. This adds to unemployment, and the number of business failures in periods of depression. Those countries that most promptly introduce efficient methods will, as a whole, have less unemployment than countries that are slow to change their methods.

Business was prosperous with the prices and wages at the level of the last five years. So prosperous that stocks were pyramided beyond reason and collapsed. A part of this prosperity was due to the small amount of money which farmers received. But if farmers had received their normal share, city business doubtless would have prospered. It will take some time before business can be equally prosperous at the new price levels which now hold.

The effects of deflation should not be confused with business cycles. At present, we are in a recession period of a business cycle. But this is superimposed on a severe depression due to deflation to a lower price level. This makes the depression doubly severe. Since the two things occur at once, there is great confusion. This is different from the depressions in 1907 and 1914 when the recovery was to a higher price level.

When Prices Fall, Cost of Distribution Remains High

Whenever prices rise or fall, distributing charges change very slowly. In 1917, during the period of inflation, food at retail in the United States

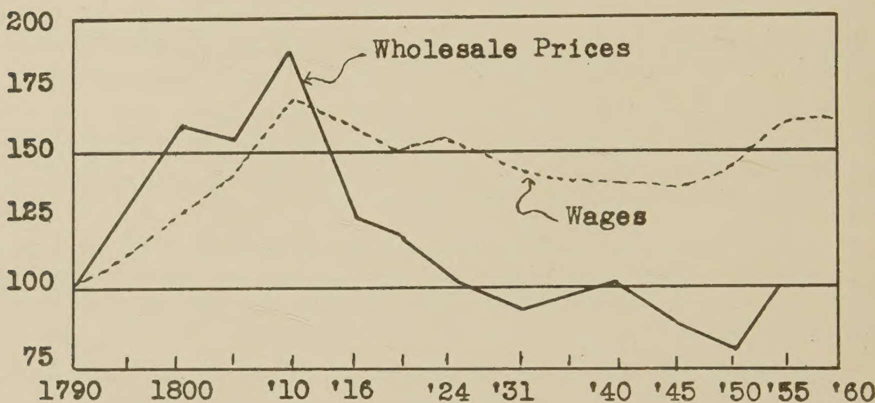

Figure 5. Wholesale prices and wages in England in the Napoleonic war period, 1790=100.

From 1810 to 1831, prices declined one-half but wages declined only fifteen per cent.

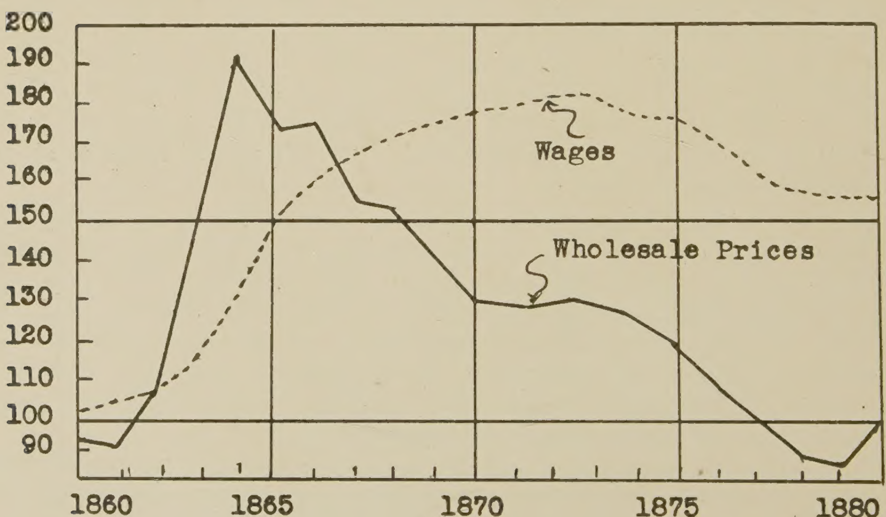

Figure 6. Wholesale prices and wages in the United States in the Civil war period, 1856-1860=100 .

Prices reached a peak in 1864, but wages continued to rise for nine years. By 1879, prices were cut in half, but wages declined only 14 per cent.

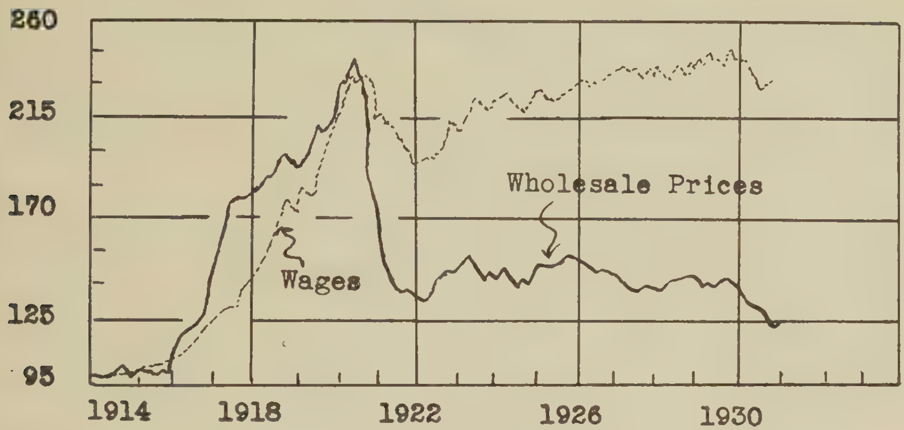

Figure 7. Wholesale prices and wages in the United States, the world war period, 1910-1914=100.

Prices reached a peak in 1920, but wages reached a peak nine years later. If prices drop as far below pre-war prices in 1935 as they did in 1879, how much will wages decline?

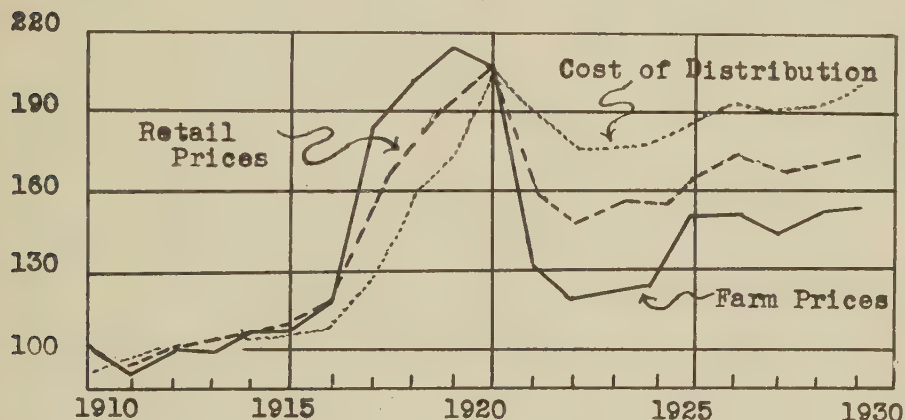

Figure 8. Prices paid to farmers for food, cost of distribution, and retail prices of the same foods, 1910-1914=100.

When inflation occurred, prices rose more rapidly than wages. Consequently costs of distribution rose slowly. Therefore, farm prices rose more rapidly than retail prices. When deflation occurred, costs of distribution remained high and farm prices were low compared with retail prices.

was 56 per cent above pre-war retail prices, but the cost of distributing food was only 29 per cent above pre-war. This gave the farmers 81 per cent above their pre-war prices.

In 1929, retail prices were much higher than in 1917, being 74 per cent above pre-war, but the cost of distributing food was 99 per cent above pre-war. Although retail prices had risen 18 points, farm prices declined 30 points and were only 51 per cent above pre-war.

It seems to be very difficult to increase efficiency in distribution as quickly as increased efficiency occurs in production.

This mal-adjustment within the price structure is the major trouble from a declining price level. It leaves prices to farmers and other producers low relative to wages, to retail prices, and to the cost of living. Debts and even taxes are less important than this.

Table 5.—*Index numbers of farm and retail prices of food and the cost of distributing food in the United States, 1910-1914 = 100.*

	1910-1914	1917	1921	1929
Retail prices of food	100	156	163	174
Farm prices of food	100	181	130	151
Cost of distribution	100	129	190	199
Wages	100	132	207	242

This problem is not merely one for agriculture. The average level of all wholesale prices in October was 121, but the cost of living was 164. This shows the same lag in adjustment of consumers' prices that food shows.

Since the charges for distribution become receipts for persons living in cities, a declining price level results in an enormous transfer of wealth from country to city. City persons must spend this extra income; a large share of it goes to better housing conditions. This results in a building boom in cities, while buildings in the country deteriorate. Such a building boom accompanied the declining prices in England following the Napoleonic Wars. A similar one, in America, followed the Civil War. A world-wide building boom in cities has accompanied the present agricultural depression. A building boom cannot go on forever. When it is overdone, reaction occurs. Following the Civil War, the reaction came in 1873, nine years after the deflation began. Following the World War, the reaction came nine years after deflation began.*

Commodity Prices Likely to Decline Below Pre-War

You asked me to discuss the outlook. Therefore, it becomes my duty to make the best possible estimate of the future rather than tell you what I would like to have the future be.

Thus far, we have had two violent declines in the level of commodity prices, one in 1920-1921, and one this year. The present decline has gone farther in most other countries than it has here, but I think that it has gone about as far as it is likely to go at present. There may be some rise from the lowest point, but I expect prices to decline below pre-war before many years.

For twelve years, I have been forcasting that the price level following the World War would, in general, follow the same course as the price level following the Civil War, that is, that prices would return to the pre-war level.† Thus far, this has been a good forecast, and I believe that it

* Warren, G. F.: Relation of Cheap Food to the Building Boom, Farm Economics, No. 9, p. 80, November, 1923.

† Warren, G. F.: Why Are Prices High? Extension Service News, Published by the New York State College of Agriculture, Cornell University, Vol. II, No. 2, p. 1, February, 1919.

will be a good forecast for the next ten or more years. I look for the average level of prices for all commodities to decline below pre-war prices because the volume of gold production in the world was checked by high prices and has by no means reached the level of production of other commodities. To have a stable price level, it is necessary that the production of gold keep pace with the production of other commodities, or that the monetary systems of the world be decidedly changed. After having as many experiences with inflation as the world has had in the last sixteen years, it is in a mood to hoard gold rather than to reduce the amount of gold back of currency. Figure 9 shows the production of gold in the World. In 1922, gold production was only 70 per cent of the pre-war amount. In 1929, it was only 89 per cent of pre-war.

During the War, most of the world ceased to use gold as money. This made it very cheap. The price level more than doubled. This meant that gold was reduced in value by one-half, or was even cheaper than wheat is now. This checked mining and increased the use of gold in the arts. Since this was to be expected, and since the renewed demand was to be expected, and an even larger demand because more business was certain, I have never been able to see anything but the probable return of gold to its pre-war value or higher.

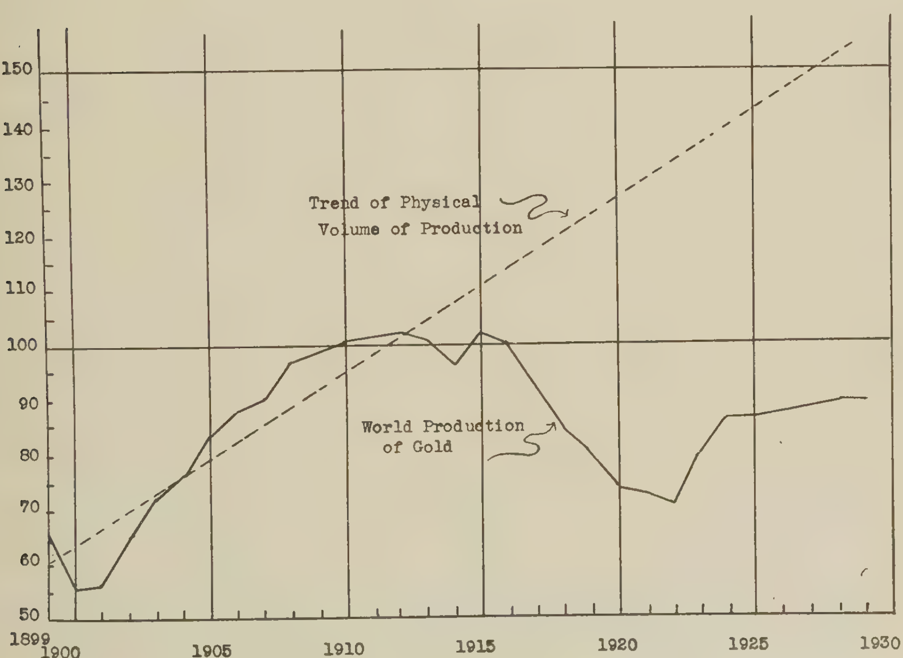

Figure 9. Trend of physical volume of production from Figure 1, and world production of gold.

From 1899 to 1915, gold production kept pace with the physical volume of production, since then, it has declined while total production of other things has continued its normal rate of increase. Gold is becoming scarce.

TABLE 6.—*World production of gold*, 1910-1914 = 100.*

Year	Fine ounces	Year	Fine ounces	Index number 1910-1914 = 100
1860	6,486,262	1900	12,315,135	
1861	5,949,582	1901	12,625,527	
1862	5,949.582	1902	14,354,680	
1863	5,949,582	1903	15,852,620	
1864	5,949,582	1904	16,804,372	
1865	5,949,582	1905	18,396,451	
1866	6,270,086	1906	19,471,080	
1867	6,270,086	1907	19,977,260	
1868	6,270,086	1908	21,422,244	
1869	6,270,086	1909	21,965,111	
1870	6,270,086	1910	22,022,180	
1871	5,591,014	1911	22,397,136	
1872	5,591,014	1912	22,605,068	
1873	4,653,675	1913	22,254,983	
1874	4,390,023	1914	21,301,836	
1875	4,716,563	1910-14	22,116,241	100
1876	5,016,488	1915	22,737,520	103
1877	5,512,196	1916	22,031,094	100
1878	5,761,114	1917	20,345,528	92
1879	5,262,174	1918	18,614,039	84
1880	5,148,880	1919	17,698,184	80
1881	4,983,742	1920	16,130,110	73
1882	4,934,086	1921	15,974,962	72
1883	4,614,588	1922	15,451,945	70
1884	4,921,169	1923	17,790,597	80
1885	5,245,572	1924	19,031,001	86
1886	5,135,679	1925	19,025,942	86
1887	5,116,861	1926	19,349,118	87
1888	5,330,775	1927	19,431,194	88
1889	5,973,790	1928	19,674,638	89
1890	5,749,306	1929†	19,590,000	89
1891	6,320,194			
1892	7,094,266			
1893	7,618,811			
1894	8,764,362			
1895	9,615,190			
1896	9,783,914			
1897	11,420,068			
1898	13,877,806			
1899	14,837,775			

*U. S. Treasury Finance Report, 1929, p. 675. The figure for 1929 is subject to revision.
†Estimated. Federal Reserve Bulletin, April, 1930, p. 170.

In the thirty years, 1860 to 1890, gold production declined. Other production increased at its normal rate. Therefore, gold became more and more valuable. We have now had fifteen years of declining gold production. Other production is increasing at a normal rate. Therefore, gold is becoming more and more valuable.

Such a situation might be remedied by the discovery of new mines or new processes, but there is no immediate prospect of either of these. It might be remedied by the establishment of a stable money, provided the population of the United States and the rest of the world thoroughly understood the causes of the depression and thoroughly understood money. But the people of the United States have spent eleven years discussing over-production. When they do turn to the money question, I fear that they

may agitate for a money less stable than gold rather than for a more stable currency.

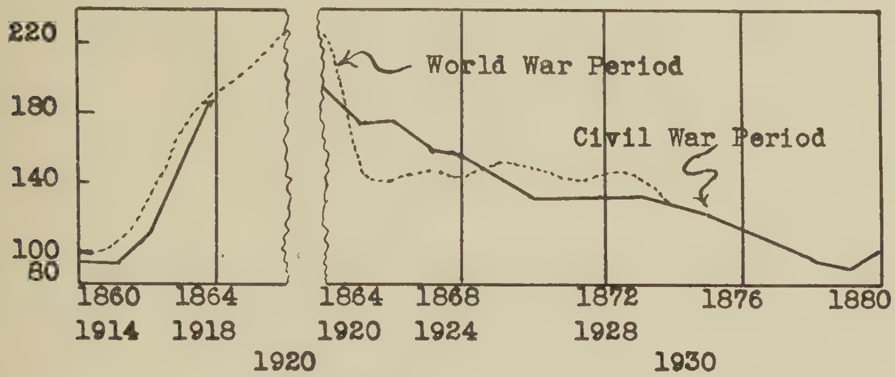

Figure 10. Wholesale prices world war and civil war period. Five years before each war=100.

Deflation has been at about the same rate in each case. It is to be expected that the similarity will continue. Prices will probably decline below the pre-war level. That is, gold will probably become worth more than it was before the war, since there is a high demand for it, and since production is not keeping pace with the production of other commodities.

Primary Remedy Is Reduced Costs of Production and Particularly of Distribution.

There are two ways of obtaining a satisfactory price; reduce production until prices rise, or reduce costs. Both ways are generally used in varying degrees. If a single product is out of line with the general level of prices, reduced production is the major remedy. If the whole price structure falls, reducing costs to correspond with the reduced prices is the major remedy.

The question is constantly asked by business men as to why the farmer does not stop producing until he can get a satisfactory price. When prices are too low, a factory closes and throws most of the burden on unemployed laborers until prices rise so that it can operate at a profit. Agriculture does adjust as surely as industry, but very slowly because of the nature of the business. A farm is a biological industry. It cannot be closed and opened at will. Because of the facts of nature, it has a very slow turnover. It is a family industry. If the farmer stops production and throws the burden on an unemployed worker, he himself is the worker that is out of a job.

It is so difficult to get settled regions abandoned, that the method of adjusting agriculture is generally to hold production about stationary while population grows. This is what is being done in food production now.

When the whole price level falls, business cannot rely on its old remedy of closing down. It also must reduce costs. Any business that attempts to hold its prices up in the face of a decline in the whole price structure is attempting to place its prices out of line with other prices. This can rarely be done for very long, unless the business is a monopoly.

If my diagnosis is correct, a year or two with some slight rise in prices will be followed by a still lower price level, and prices will ultimately go below pre-war.

If this is the basic trouble, the procedure will be entirely different from what it would be if over-production is the trouble. The adjustments to make are:

1. Find ways of producing farm products with less hours of labor.

2. Find ways of reducing costs of distribution.

3. For certain products, increase the quality to meet the new demands for quality from workers who have a high buying power.

4. Not being able to increase efficiency or reduce distributing charges fast enough, total food production is being reduced or held about stationary while population grows. This will help farm prices and will result in a period when consumers' prices of food are high compared with other things, that is, a period of "high-cost-of-living."

If the trouble is over-production, the charge that extension work and scientific research are to blame may have a grain of truth in it. But if the trouble is monetary, and if we must learn to produce at a profit with prices at pre-war levels, and wages far above pre-war, then there was never before a time when research and education should be pushed with more vigor. Farmers must know how to adjust and act quickly.

Scientific research, agricultural extension teaching, the use of improved machinery, greater output per man, are not the causes of the depression, but are the major ways in which the depression can be met. The farmer, the manufacturer, or the country that cannot increase efficiency quickly will be left behind.

If my diagnosis is correct, the individual farmer must anticipate still lower prices a few years from now, except for products that are already below the general price level. These will probably rise and later fall again. He should be careful about long-time debts, except for things that are below pre-war prices.

He should not buy land nor work land that does not give a high output per hour of labor. He should have a business large enough to fully employ all his time and that of his labor. He must get more bushels of grain and more pounds of milk per hour of labor. The chief ways of doing this are by obtaining more milk per cow, higher crop yields per acre, and by using labor more efficiently.

Higher crop yields should be obtained by dropping out of use, the fields that do not give high yields. Such fields may be used for pasture or, if very poor, may be left idle. This often means renting, or buying all or part of an adjoining farm and working only the best land on both. There are some entire farms that should be abandoned, and some whole regions should go out of use. There are many of these particularly in the hill lands from New York to Georgia, and from Missouri to Cape Cod. Much of this land should be purchased for State and national forests.

The fields that are used for cultivated crops should be well fertilized and well cared for. Fertilizers are cheap, but wages are high. More care in using good seed, attention to disease control, and the like are essential. Such changes mean more production per man, but mean fewer men and some reduction in total agricultural production. How much reduction occurs depends on how many acres are thrown out of use or into lower classes of use.

Occasionally, as in western Kansas, a region of low yields per acre can be used because a new machine comes in and makes the output per man very high with low yields. But even in this region, high yields for the region are very important.

Labor may be made more efficient by the greater use of autos, trucks, tractors, and other machinery. Labor-saving plans are often more important than machinery. Methods of doing work at the time and in the manner that make an hour count for the most are of unusual importance.

Since the primary difficulty at the present time is the discrepancy between producers' prices and consumers' prices, this is particularly severe on agriculture. Most manufacturers buy at wholesale prices which are low and sell at wholesale prices which are also low. But, in general, agriculture buys at retail prices which are high and sells at wholesale prices which are low. Both agriculture and industry have the problem of increasing efficiency to such an extent that they can pay labor a much larger quantity of the products for a day's work than was formerly paid. Both industry and agriculture have the tax problem, but only agriculture has the problem of selling at wholesale and buying at retail prices.

Since this is the case, it is particularly important that farmers attempt to get nearer to consumers before they sell and that they reach nearer to wholesalers in their buying. Some farmers are so near cities that they can truck their products to the city, but for most farmers, the feasible way of doing these two important things is through coöperative associations. For example, the Pacific Egg Producers have established headquarters in New York City where they sell to wholesalers and retailers. Coöperative buying associations such as the G.L.F. (Grange League Federation Exch., Inc., Ithaca, N.Y.) in the Northeastern States are of special value because they buy farm supplies from the producer and carry them all the way through to the farmer at retail.

If the Government wishes to encourage coöperatives, it should encourage buying associations as well as selling associations. The Intermediate Credit Banks and the Farm Board Acts should be amended so as clearly to recognize coöperative buying.

The individual farmer can often cut out some of the costs of distribution, by use of trucks, by selling to truckers, and sometimes by retailing. In the 16 leading markets, 29 per cent of the hogs and 13 per cent of the cattle now arrive by truck. Eggs are taken 200 miles to New York by truck. Much of the milk for Chicago comes in in tank trucks. Fruits and vegetables are coming to city markets by trucks. Each large city needs a large wholesale center where railroads, farmers' trucks, and commercial truckers meet wholesale and retail buyers and inter-city truckers who distribute from this center.

When nearly all the time of human beings was spent in obtaining bare necessities, quality of food was not very important. But decade after decade as the proportion of the income that goes for food is reduced, the increased buying power is in part spent for choicer foods. Deflation suddenly increases the demand for better foods. Even in the present depression, the demand for Grade A milk in New York is holding up better than the demand for Grade B milk. Farmers who produce fruits and vegetables have made profits out of the depression by being first to recognize the sudden demand for quality. This is, of course, a less important item for the staple crops.

Vigorous attention should be given to our taxation system.

The agricultural colleges should take an active part in studying distribution. The colleges were originally biological institutions. Many of the directors and most of the faculty are men who are trained in Botany, Chemistry, Physics, and the like. Very often, these men do not understand, and often do not look kindly upon such subjects as: Farm Management, Marketing, Prices, Statistics, Coöperative Marketing, Business Management, Accounting, Public Affairs, Farm Finance, Farm Insurance, Land Economics, and similar fields of study.

When farming was a home industry, the problems of production were the primary ones. The rising price level from 1900 to 1920 also made production particularly important. Now these new problems are as important as production.

These subjects should not be looked upon as a single department in a college, but should be looked upon as the equivalent of Agronomy, Soils, Plant Breeding, Pomology, Floriculture, Vegetable Growing, Forestry, and the like, all combined. In other words, the whole field of Plant Industry is no more important for study than is this broad collection of subjects dealing with economics, distribution, public affairs, etc. If these problems are to receive adequate attention, it will be as a result of demands made by farmers.

Some Commodities Will Rise in Price

Although the general price level probably will fall, some commodities are already so low that they will undoubtedly rise. Wheat is below pre-war prices and will undoubtedly rise. Only once since 1797 has the purchasing power of wheat been lower than it has been this fall. In 1820, the purchasing power, that is, its price compared with the average of all commodities, was 49. On November 11, this year, it was 61. The next lowest purchasing power was in 1894 when it fell to 71. In each case, the low purchasing power was preceded by normal prices. In each of the previous cases, low prices were followed by normal prices in a year or two. Undoubtedly, this experience will be repeated. Of course, there will be years of high prices and years of low prices, but wheat is very stable in comparison with prices of other commodities, and promises to remain so. The relatively small amount of wheat which is coming out of Russia is generally taken to indicate that there is a flood of wheat for sale, or that the Russians are trying to make war on other countries. The more probable explanation is that after many years of war and turmoil, Russia is extremely short of machinery

and is willing to sell whatever she has to get it, and also that it rained in Russia last summer. The total amount of wheat exported by Russia is not high.

City Real Estate Must Adjust to a New Cost Basis

The production of automobiles and many other short-time goods is so low that increased business activity is to be expected next year. But only a mild prosperity can occur so long as city real estate is not adjusted to the new price level, i.e. to new costs. Thus far, the holders of property and mortgages have been putting off the evil day of adjustment. In the similar period following the panic of 1873, which corresponds to 1929, it was nearly seven years before real estate was adjusted so that general city prosperity returned. Probably the next business cycle will be a period of mild prosperity, followed by the usual depression and then by real prosperity in five or six years. In the meantime, much city property will probably have to change hands at prices below even the new costs of production, as usually happens in a readjustment period. Good city houses like good farms have a permanent value, but at times, the market may be poor.

I am sorry that this paper has to be somewhat pessimistic because it expects the general level of prices to go below pre-war in the next five to ten years. If I am right, it is much better to make the necessary adjustments rather than hope for a remedy through a return to the price level of 1929.

City homes will decline in value because of lower costs of construction. This is pessimistic for the man who wants to sell, but the cost of building new homes and barns will be less. This is optimistic for the one who wishes to build. Hired labor will continue to cost the farmer much more than before the War. This is pessimistic for the farmer who depends on hired labor, but the farmer's own time will also be worth more. This is optimistic for the man who works effectively. Land that gives a very low production per hour of labor has no value for farming. This is pessimistic. Land that will give a high yield per hour of labor is very valuable. The sooner the poor land is turned to forest use, the better.

There is some consolation in the fact that the two largest price drops are behind us, one in 1920-1921, and one this year, and all of us who are here are still alive. In such a period of adjustment, not all the years are bad years. Nor are all farmers in distress. Some have made money in the past ten years. There are still opportunities for financial success, but all business acts must be based more on reason and less on tradition.

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OMISSION

On the opposite page are two plates omitted in making up the March issue of *Scientific Agriculture*. They belong to the article by Mr. C. W. Leggatt on "Further Studies on the Hard Seed Problem; Alfalfa and Sweet Clover". Reference to them will be found on page 422, Volume XI., No. 7. We regret that this error occurred.

Plate 1. Sweet clover yield plots. 1928 seeding, Brooks. Right side of picture, scarified sample; left side, unscarified sample.

Plate 2. Sweet clover yield plots. 1929 seeding, Brooks. Right side scarified, left side unscarified. The unscarified seed plot with a sparser stand shows a coarser type of growth.

THE ORGANIZATION OF AN AGRICULTURAL ECONOMICS DEPARTMENT *

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Human knowledge is not a collection of fields. If we are to discuss it in terms of two dimensions, it must be as a vast, mostly unexplored plain in which there are no such things as divisions. As knowledge progresses, we come to see that such divisions of knowledge as physics and chemistry are purely artificial and that in fact, there is no division whatever. The old definitions showing a division between physics and chemistry were based on ignorance of the facts. The arbitrary division where no division exists has seriously interfered with progress in the search for truth. This has often prevented a student from obtaining a sufficiently wide training in fact and in technique so that he could attack a problem successfully.

We are also coming to see that there is no longer such a thing as pure or applied science. All science is now applied. In attacking any problem, knowledge and technique of many types are brought into use. Since all knowledge is a unit, any problem may trespass on several of the old so-called sciences.

But organization is necessary to get work done and to handle finance. The best method of organization depends on the amount of money to be spent and on many other questions. The organization that is best for today is not best for a generation hence.

When work in forestry was first started, it was generally by botanists or horticulturist. But little progress was made until it was recognized as a department or a college.

When animal husbandry was begun, it was sometimes in chemistry, sometimes in zoology. (I believe that in some colleges in Scotland, it is still in the hands of the zoologists.) But as more money has been spent on it, it has been found better to have departments of animal husbandry.

Usually, the first work in farm management was done by agronomists because agronomists were thrown in more intimate contact with the farm as a whole than were most of the other workers. From work on one crop to crop rotation and then to the farm as a whole were relatively easy steps. Larsen of Denmark was a county agent who had specialized in agronomy. He got started on farm accounting and developed the excellent work which he is now doing in agricultural economics. This work has been set up as a separate administrative unit in the national government and in the agricultural college.

The same history is illustrated in most countries. In the United States, Spillman was an agronomist who became interested in the farm as a whole. He organized the work in Farm Management in the Department of Agriculture and I understand made the plan for the Bureau of Markets.

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*A talk before the Canadian Society of Agricultural Economics meeting in affiliation with the C.S.T.A. at their tenth convention, Wolfville, Nova Scotia, June 25, 1931.

†Professor of Agricultural Economics and Farm Management.

Boss of Minnesota was an agronomist who got started in farm management by way of accounting. Hunt was also an agronomist.

If my own experience is worth mentioning, it would be even more diverse, as I first specialized in mathematics, then took a master's degree with a major in soils, and specialized in horticulture and agronomy for a doctor's degree.

Taylor was the only one of the earlier workers in the United States who came into the field from general economics, and he had previously graduated from an agricultural college.

In 1911, farm management in the United States was taught in various departments as follows *.

Same department as Agronomy	25	colleges
Department of Agricultural Economics	3	"
Separate department	3	"
Same department as Animal Husbandry	1	"
Same department as Agricultural Extension	1	"

In the United States Department of Agriculture, Farm Management was first in the unit with Agrostology because Spillman was there. It was then made a separate division. An independent division of crop reporting developed. Later, the Bureau of Markets was established. Still later, these were all combined and the work expanded to make the present Bureau of Agricultural Economics.

Just as there is no such thing as a division in human knowledge, so there are no hard and fast divisions between the different kinds of work in agricultural economics.

In agricultural economics and related subjects, different points of view may be emphasized, as follows:

1. Farm Management, or the point of view of the organization and management of a farm for the purpose of decreasing costs of production and making the greatest continuous profit for the operator.

2. Marketing. This includes the organization and management of agencies which have to do with the buying and selling of farm products and farm supplies. Just as farm management gives a large amount of attention to decreased costs of production, this work gives a large amount of attention to decreased costs of distribution.

3. The field of public affairs has not yet been given a satisfactory name. For lack of a better name, I will call it Rural Economy. This may be said to be the organization and management of government service for the purpose of obtaining efficient service at lowest cost, and otherwise giving attention to agricultural welfare. It, of course, includes some other problems.

4. Since man does not live by bread alone, attention must be given to social problems. We might say that farm management is the problem of making the farm a business success; marketing, the problem of successful operation of distributing agencies; rural economy, the problem of successful

*Second annual report of the American Farm Management Association, p. 7, Nov. 1911.

operation of public agencies; and rural sociology, the problem of making rural life a success. Of course, like any other brief definitions, these are too limited.

Many problems such as prices cut across all or most of the lines of work.

But this analysis makes the problem too simple. All research work is by projects. For example, some of the problems on which work is being done are:

Cost of operating tractors, economic effects of tractors on farms, such as replacement of horses on farms, labor saved, effect on crop yields, on size of farms, on tenure, costs of production, etc.

How do prices respond to quantity of supplies; what are the responses of farmers and consumers, to price changes?

Principles underlying the successful operation of feed stores.

How to operate a coöperative fire insurance company.

Problems on rural electrification.

Rural road questions—who uses the roads, and who pays for them; what is the value of roads to farms?

How to conduct the business affairs of a rural township, or a county, or a hospital?

Land utilization policy for a State.

Land appraisal for the purpose of making loans, etc.

Any one of these problems will call for the use of many types of knowledge. For example, a study of land appraisal involves a knowledge of geology, meteorology, soils, agronomy, animal husbandry, farm management, prices, taxation, roads, and the like.

The history of the work in all countries indicates that for the best results, the work in these fields should be an independent unit or collection of units.

Just as animal husbandry develops best when separated from zoology, and horticulture best when not a subhead under botany, soils, or general farm crops, so the best work in marketing, and farm management is being done when these are based on a knowledge of other agricultural sciences such as agronomy and animal husbandry, etc., but not controlled by them. It is just as logical to have animal husbandry in a farm management department as to have farm management in a department of animal husbandry.

The work also develops best when not a sub-head under economics or business administration. When any part of the field of agricultural economics is dominated by economics or business administration, there is a strong tendency to emphasize economics but to forget the agricultural basis of the work. For example, in any study of farm taxation, the person doing the work should know farm management and soils; but this, in turn, calls for a knowledge of geology, meteorology, etc.

If an attempt is made to develop these subjects in departments of animal husbandry and agronomy, the tendency is to limit the field and

neglect the economic background. If the attempt is to develop the work in a department of economics, the tendency is to neglect the agricultural background.

One has only to look over the published research work in the various countries and to compare the expenditures made under various methods of administration to be convinced that for both quality and quantity, the workers in the field of agricultural economics should know the agricultural sciences such as soils and feeding, and the sciences back of these, and should also know economics and statistics. Workers, thus prepared, turn out the greatest quantity and the best quality of work when in departments that are independent, that is, not combined with either economics, or agricultural sciences such as animal husbandry and agronomy.

If the institution has sufficient funds, it is likely to get the best results by having several departments such as Farm Management, Marketing, Rural Economy, Rural Sociology, Prices and Statistics.

THE INFLUENCE ON YIELD AND GRADE OF HARVESTING RUSTED WHEAT AT DIFFERENT STAGES OF MATURITY * †

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Introduction

In the spring wheat region of Western Canada the stem rust disease of wheat is one of the most influential factors in determining crop yield and quality. The frequent occurrence of destructive rust epidemics has emphasized the tremendous importance of the disease. Unfortunately, the belief has become more or less common that, in rust years, grain yield and quality are reduced by allowing badly rusted wheat to stand until it is fully mature.

In an effort to secure more definite information regarding the problem of harvesting rusted wheat, studies were commenced at the Dominion Rust Research Laboratory, Winnipeg, Manitoba. The primary object of the investigation was to determine whether or not significant differences in yield and grade could be obtained by harvesting rusted wheat at different stages of maturity. An attempt was made also to discover if there were any indications that food materials stored temporarily in the stems and leaves, were translocated to any appreciable extent to the kernels after the wheat had been cut.

In 1927, 1928 and 1929, field experiments were carried out in Manitoba. Each year definite yield data were secured. These data were analyzed statistically and studies were made of the influence of time of cutting on the quality of the grain.

Review of Previous Investigations

Studies on the stage of development of the wheat plant in relation to the assimilation of plant food have been reported by Snyder (*21*), Gericke (*14*), Brenchley and Hall (*8*), Thatcher (*24*); Swanson (*23*), Bailey (*4*), Saunders (*18*), Shutt (*20*), and others. In general, the results show that during the early growing stages of the wheat plant, mineral nutrients are taken up with remarkable rapidity, and stored temporarily in the leaves and stems. During the filling period these elaborated food materials are transferred to the kernels.

The question of food translocation in cereal plants harvested before they have reached full maturity, seems to require further investigation. According to Adorjan (*1*) the greatest portion of the necessary plant foods is absorbed during the early stages of growth, and is used as the plant develops. He concluded that by the time the plant is in flower practically enough plant food has been assimilated to enable it to function normally to maturity. Bedford (*5*) cut samples of wheat at different stages of growth and decided that wheat harvested in the dough stage yielded as high as that cut at maturity. The work of Saunders (*18, 19*) would indicate that grain

*Contribution from the Division of Botany, Experimental Farms Branch, Department of Agriculture, Ottawa, Canada.

†It is a pleasure to record my indebtedness to Dr. C. H. Goulden, of the Dominion Rust Research Laboratory, for advice and much valuable assistance with the statistical portion of this paper.

‡Plant Pathologist.

crops may be harvested before they are mature without noticeable loss in yield and quality.

Investigations of the influence of time of cutting on the yield and quality of rusted wheat have been made by Stoa (*22*), Arny (*2*), and Arny and Sun (*3*). In a more recent paper Wilson and Raleigh (*25*) have given a complete review of the literature, and summarized the results of their studies involving the effect of harvesting badly rusted wheat and oats at different stages of maturity. In general, the results of these investigations show that there is no advantage to be gained by harvesting rusted grain crops prematurely.

In Western Canada, Bracken (*7*), Ellis (*9*), Fraser (*13*) and Harrington (*16*), have given considerable attention to the problem. The studies of these workers have indicated that badly rusted wheat should be harvested like healthy non-rusted wheat, that is, as soon as the kernels have reached the hard dough stage,—two or three days before it is fully mature.

Although a good deal of evidence has been presented to show that badly rusted wheat should be allowed to ripen, in most of the cases definite yield results were not obtained and conclusions have been based on experiments carried out in one year. In the present study it was thought that the practical significance of the yield results would be increased if comparable results could be obtained in different years. Each year of the experiment, yield data were secured, and an effort was made to determine whether significant yield differences existed between badly rusted wheat harvested at different stages before maturity and a diseased crop cut when fully ripe.

Methods

In experiments to determine the effect of harvesting rusted wheat at different stages of maturity, use was made of small blocks of clay loam soil which had been under summer-fallow the previous season. In 1927, an experimental field was located in each of the districts of Winnipeg, Thornhill, and Graysville, and two fields were located at Morden, Manitoba. The experiments were carried out on the College Farm, Winnipeg, in 1928 and 1929.

In each year of the experiment, the experimental fields were sown late to Marquis wheat. An ordinary seed drill, with drills six inches apart, was used. It was hoped that the late sowing on well prepared soil would afford conditions favorable for a rank succulent growth which would become naturally infected with leaf rust (*Puccinia triticina* Erikss.) and stem rust (*Puccinia graminis tritici* Erikss. and Henn.).

Harvest was started when it was estimated that the wheat should reach full maturity within 12 to 14 days. An epidemic of leaf and stem rust had then become thoroughly established in the experimental wheat plots. The prevalence of a severe rust epidemic delayed maturity, and in 1927 particularly, extended the harvest over a longer period than was originally anticipated, the first cutting being made 18 days before maturity.

Each year, beginning with the first day of harvest, a row, consisting of the ordinary drill row, one rod long, was harvested from different sections of the field. The second harvest was made two or more days later by cutting the rod drill rows one foot to the right of the harvested rows. The

TABLE 1.—*Percentage of leaf and stem rust, yield per rod row and yield in bushels per acre, of rusted Marquis wheat harvested at different stages of maturity at Morden, Thornhill, Graysville, and Winnipeg, Man., in 1927.*

Field	Date of harvesting	Stage of maturity of kernels when cut	Percentage severity of rust		Yield per rod row grams	Yield per acre bushels
			Leaf	Stem		
Morden A	August 19	thick milk	30	45	73.9	14.3
	" 25	soft dough	55	65	104.3	20.2
	" 31	thick dough	60	85	118.7	23.0
	September 6	hard dough	60	90	128.2	24.8
Morden B	August 19	thick milk	40	65	63.5	12.3
	" 25	soft dough	40	80	92.2	17.8
	" 31	medium hard dough	55	80	101.3	19.6
	September 6	starchy	60	85	109.0	21.1
Thornhill	August 19	thick milk	40	40	61.2	12.0
	" 25	soft dough	55	55	78.1	15.1
	" 31	hard dough	60	70	114.2	22.1
	September 6	hard starchy	60	75	112.1	21.7
Graysville	August 19	thick milk	35	65	48.2	9.3
	" 25	hard dough	55	65	74.7	14.5
	" 31	thick dough	55	85	77.6	15.0
	September 6	hard starchy	55	85	85.0	16.5
Winnipeg	August 19	thin milk	40	45	45.5	8.8
	" 25	soft dough	50	75	65.3	12.6
	" 31	thick dough	65	75	64.1	12.4
	September 6	hard dough	65	85	68.2	13.2

third set of samples was secured by cutting rod rows one foot to the left of the first rod rows harvested. At each subsequent date of harvest rows were cut alternately to right and left of the earliest harvested rows. In 1927 and 1928, ten rod rows were cut at each date of harvest for yield and quality studies, and in 1929, twenty-five rows were cut.

Each row was cut with a sickle about three inches above the ground, tied in a bundle, and the heads enclosed in a cotton bag. The bundles were shocked together and left to dry in the field. After ten days in the shock, the sheaves were removed to the threshing shed. Each rod row was threshed separately and the yield of grain recorded.

Observations on the stage of maturity of the wheat plants were recorded when each cutting was made. The condition of the kernels in the centre spikelets was used as an index of maturity.

The percentage severity of stem and leaf rust was determined for each date of harvest. These readings were made according to the usual standard, where 37 per cent of the actual surface covered with rust is arbitrarily selected as 100 per cent.

Since the resulting yields and grades of rusted wheat harvested at different dates constitute the important evidence in this study, determinations were made of weight of 1000 kernels, percentage of green kernels, yield per rod row, weight per bushel, commercial grade and yield per acre in bushels, for each date of harvest.

The yield per rod row was computed for each date of harvest by averaging the weight of grain obtained from the rows of each cutting. The yield in bushels per acre was calculated from the average weight per rod row. The weight of 1000 kernels was ascertained from the average of quadruplicate lots of 500 kernels, each of which was weighed on an analytical balance. The percentage of green kernels was found by counting the number of kernels in the four 500-kernel lots used for the weight determination which showed a decided green tinge. In 1929, the percentage of shrunken kernels was also computed from a count of 1000 kernels. Kernels showing a distinctly shrivelled or shrunken condition were considered in one class as shrunken. Weight per measured bushel was determined by bulking the threshed grain of each cutting and weighing according to Dominion Government Grain Standards. In order to establish the correct marketable grade for the various cuttings, threshed samples were submitted to officials of the Western Grain Inspection Division, Winnipeg, Manitoba.

Experimental Results

Experiments in 1927

In 1927, conditions were exceedingly conducive to the development of a rust epidemic which was comparable in its destructiveness to the outbreaks of 1916 and 1923. The season proved to be very favorable for studying the effect on yield and grade of harvesting rusted wheat at different stages of development.

In Manitoba, primary infections of stem rust were first observed on July 6. A few primary infections of leaf rust were found in the experimental fields at Morden as early as June 22. On July 18, a general infection of stem rust was present in southern Manitoba. At this time leaf rust was

TABLE 2.—*The average yield in grams per rod row of five fields of rusted Marquis wheat, harvested at different stages of maturity in 1927, and the statistical estimation of the difference between the yields of rusted wheat cut eighteen, twelve, and six days early, and rusted wheat harvested at the normal time of maturity.*

Field	Date of harvest			
	August 19	August 25	August 31	September 6
Morden A	73.9	104.3	118.7	128.2
Morden B	63.5	92.2	101.3	109.0
Thornhill	62.2	78.1	114.2	112.1
Graysville	48.2	74.7	77.6	85.0
Winnipeg	45.5	65.3	64.1	68.2

Cuttings compared	*Mean differences*	t
Aug. 19 — Sept. 6	41.8	7.49
Aug. 25 — Sept. 6	17.6	3.27
Aug. 31 — Sept. 6	5.3	2.60

5% point = 2.78

general and fairly abundant. By July 25, the amount of stem rust had increased to a remarkable degree, and in all districts leaf rust was extremely heavy, the whole leaf surface being generally covered.

Weather conditions during July and early August remained favorable for the development of rust, and by August 19, when the first harvest was made, the rust epidemic was well established in all fields under experiment. Heavy infections of leaf and stem rust occurred. The season was decidedly unfavorable for finishing off the late rusted wheat crop, and, as a result, the yield and grade of wheat allowed to reach full maturity was reduced. Under the conditions of the experiment the injury caused by pests and diseases other than rust, was almost negligible.

The date of harvest, stage of maturity, and the per cent stem and leaf rust severity at the time the various cuttings were made, with the average yield per rod row and the yield in bushels per acre of five fields in Manitoba, are presented in table 1. In this study the average weight per rod row and the weight of random samples of 1000 kernels was considered to be of major importance.

The significance of the rod row yield results was determined by the direct pairing method. This consists of finding the difference between the two items compared and their mean difference. From this mean the standard deviation of the several differences is found by the usual formula: $\text{S.D.} = \sqrt{\frac{fd^2}{n}}$. The ratio of the mean difference to its standard deviation is designated as t, the distribution of which has been calculated by Fisher (*11*) from "Student's" distribution of the mean of small samples. Fisher's tables were used here in order to determine the significance of t.

The average yield in grams per rod row of five different fields, and the statistical calculation of the significance of the mean difference between the rod row yields of rusted wheat harvested 18, 12, and 6 days early, and rusted wheat harvested at maturity, are given in table 2.

In determining the difference between cuttings made on August 19 and those made on September 6, a t value of 7.49 was obtained. Since a t value of 4.6 gives 100:1 odds, the difference observed here is significant. A significant yield difference was observed also between wheat harvested August 25 and September 6. The significance of the difference between paired values of cuttings made seven days early and at maturity was tested and a t value of 2.6 was obtained. Using Fisher's tables it is evident that the odds of significance are less than 20:1.

Weight in grams of 1000 kernels for the grain harvested at successive stages of development and cured under identical conditions, are recorded in table 3. With increase in yield per rod row it might be expected that an increase in 1000-kernel weight would be shown. The results in table 3 confirm the expectation. It should be noted that the increase in weight is extremely rapid from the time the kernels were in the thin milk stage (August 19) to the thick or hard dough stage (August 31). After this the increase is not so marked. The gradual though continuous gain in kernel weight of rusted Marquis wheat between August 19 and the time of full maturity, indicates clearly the advantage to be gained by allowing heavily

TABLE 3.- *Effect on 1000-kernel weight, number of green kernels, weight per bushel and grade, of harvesting rusted wheat at different dates, in 1927.*

Field	Weight of 1000 kernels grams				Percentage of green kernels				Weight per measured bushel, pounds				Government Grade			
	Aug. 19	Aug. 25	Aug. 31	Sept. 6	Aug. 19	Aug. 25	Aug. 31	Sept. 6	Aug. 19	Aug. 25	Aug. 31	Sept. 6	Aug. 19	Aug. 25	Aug. 31	Sept. 6
Morden A	14.9	18.7	19.9	19.8	71.4	41.0	17.2	15.3	47.0	53.5	53.5	56.0	Feed	6	6	4
Morden B	19.5	21.5	23.8	23.9	40.8	19.9	13.0	7.2	54.0	55.0	59.0	60.5	6	6	4	3
Thornhill	20.0	21.4	22.7	21.2	63.1	24.9	10.9	5.4	55.0	57.0	58.5	58.5	6	4	4	4
Graysville	16.2	18.7	20.0	23.6	45.5	30.7	11.4	4.8	48.0	49.5	54.0	54.0	Feed	Feed	6	5
Winnipeg	11.4	11.8	13.4	14.4	92.1	86.7	43.4	31.4	43.0	43.0	49.0	54.0	Feed	Feed	Feed	6

TABLE 4.—*Leaf and stem rust severity, yield per rod row, and yield in bushels per acre of rusted wheat harvested at different stages of maturity at Winnipeg, in 1928*

Date harvested	Days to maturity	Stage of maturity of kernels	Per cent leaf rust severity	Per cent stem rust severity	Average yield per rod row grams	Yield per acre bushels
August 23	15	thin milk	40	5–10	94.7	18.3
August 26	12	thick milk	45	20	115.1	22.3
August 29	9	soft dough	55	25	122.6	23.7
September 1	6	thick dough	62	40	122.9	23.8
September 4	3	hard dough	65	55	139.3	27.0
September 7	mature	starchy	65	55	147.3	28.5

rusted wheat to mature. The yield results presented in table 2 are substantiated by the increase in kernel weight results as shown in table 3. The relative weights of random samples of 1000 kernels are also clearly indicative of the quality of the threshed grain.

The failure of the kernel weight of wheat cut before it was fully mature to approach that cut at later stages of maturity indicated that food materials are not transported to any degree from the straw to the grain after cutting. This data supports the evidence obtained by Saunders (*18*), Failyer and Willard (*10*), Arny and Sun (*3*), Wilson and Raleigh (*25*), and others.

In considering grain quality, the color of the kernel is an important factor. The percentage of green kernels, as well as the weight per measured bushel and grade for the different harvest dates, are presented in table 3. It will be found that the percentage of green kernels in the early cuttings is exceedingly high. When the grain was cut later, the number of green kernels was reduced. As already stated, the harvest season of 1927 was extremely unfavorable for the proper curing of grain, so that even when the wheat was allowed to stand until it was fully mature, a considerable percentage of the kernels remained green in color. However, there was a decided reduction in the number of green kernels in the later cut material.

The weights per measured bushel of wheat harvested August 19, 25, 31, and September 6, are summarized in table 3. From August 18 to September 6, the increase in bushel weight is uniform and gradual for each field. These data substantiate the yield and kernel weight results and show that the weight per bushel of wheat harvested in the more immature stages was lower than for the wheat cut at maturity.

The official market grades are indicative of the effect of early cutting of rusted wheat on the quality of the threshed sample. Although the general quality of the wheat crop in Manitoba was considerably below normal in 1927, there was a decided difference in grade when the various cuttings from the experimental plots were compared. The results in table 3 show that the quality was remarkably improved by allowing rusted wheat to mature.

Although it is not advisable to draw conclusions from the results of one year, a comparison of the yield results obtained when rusted wheat was harvested at different stages of maturity is at least indicative. The results show that the early harvesting of rusted Marquis wheat was an exceedingly unprofitable practise in 1927.

Experiments in 1928

The date-of-cutting investigation started in 1927 was continued at Winnipeg in 1928. For the purpose of the investigation a small field was sown with Marquis wheat on May 17.

In 1928, ideal conditions for the development and spread of rust prevailed in Manitoba. The amount of precipitation during June and July was considerably above the normal, and heavy stands of grain were prevalent throughout the wheat-growing districts of the province. Nevertheless, a general rust epidemic did not occur. Epidemiology studies undertaken at the Dominion Rust Research Laboratory seemed to indicate that the absence of rust in general epidemic form, was correlated with the scarcity of early inoculum and the rapid ripening of the grain in early August. Notwithstanding the general light spread of stem rust, the disease

TABLE 5.—*Yield in grams of individual rod rows of rusted Marquis wheat harvested at different stages of maturity at Winnipeg, Man., in 1928, and the statistical estimation of the difference between the yield of rusted wheat cut from 15 to 3 days before maturity, and rusted wheat cut at the normal time.*

Rod Row No.	Date of harvest					
	August 23	August 26	August 29	September 1	September 4	September 7
1	44	113	121	126	151	144
2	88	141	111	117	163	181
3	99	136	114	175	126	145
4	115	122	140	150	126	118
5	129	127	139	74	125	147
6	76	160	168	136	165	165
7	124	105	119	114	182	193
8	83	87	85	145	98	77
9	86	74	121	116	143	138
10	103	86	108	76	114	165

Cuttings compared	*Mean differences*	*t*
August 23 - Sept. 7	52.6	14.0
August 26 - Sept. 7	32.2	2.9
August 29 - Sept. 7	27.0	5.9
Sept. 1 - Sept. 7	24.4	1.4
Sept. 4 - Sept. 7	8.0	1.2

5% point = 2.26

reached epidemic proportions in a few areas. In the Winnipeg district, late-sown Marquis wheat was severely attacked.

Stem rust of wheat was first reported from the southern part of Manitoba on July 12. Scattered pustules were discovered on plants in the experimental field at Winnipeg, July 15. By July 22, a trace of stem rust was generally present. In late sown fields of Marquis wheat, stem rust infection was unusually light and variable during the first two weeks of August, but during the latter part, a fairly uniform and heavy infection developed. Leaf rust infection was general and exceedingly heavy on susceptible wheat varieties.

In 1928, a severe frost occurring on August 28, caused considerable damage to the late wheat stands. Undoubtedly, the quality of wheat sown as late as May 17 was decidedly influenced by this factor. It cannot be considered then, that rust was wholly responsible for the low yield and grade of mature wheat harvested from the experimental plots.

For the purpose of the study, yield data were obtained by harvesting ten rod rows at three-day intervals commencing August 23, and continuing until the crop was ripe (September 7). On August 23, the kernels of the centre spikelets had reached the thin milk stage and the terminal spikelets and leaves were still green. By September 4, the wheat was in the hard dough stage, and by September 7 normally ready to harvest. Observations were made on the stage of maturity of the wheat, and on the percentage infection of leaf and stem rust at each date of harvest. Yield and quality determinations were made according to the methods used in 1927.

The percentage severity of leaf and stem rust together with the yield per rod row in grams, and the yield in bushels per acre, of wheat harvested at 15, 12, 9, 6, and 3 days before, and at maturity, are presented in table 4.

The significance of the rod row yield results was determined by the direct pairing method. The significance of the difference between the paired values was tested by the method given by Fisher. Yield per rod row of the different cuttings, and the statistical calculations of the experimental data are presented in table 5.

In determining the significance of the difference between wheat cut when the kernels were in the thin milk stage (15 days early) and that cut at maturity, a t value of 14.0 was obtained. Since a t value of 3.25 gives 100:1 odds, the difference observed is highly significant. When the paired values of cuttings made August 26 and September 6, and August 29 and September 6, were tested, the differences observed were quite significant. The differences in yield observed when cuttings were made six and three days early were not significant.

By August 29, rust was sufficiently well established to cause considerable damage to the maturing grain. It is important to notice that, although the percentage infection of rust increased as the grain ripened, an increase in yield was realized when the wheat was left to mature.

Along with the significantly lower yield of the early cut wheat it might be expected that differences in weight of kernel, weight per measured bushel, and number of green kernels, would exist. This expectation is confirmed by the data summarized in table 6. Rusted wheat cut at different stages of

TABLE 6.—*Effect on the weight of kernel, percentage of green kernels, weight per measured bushel and grade, of harvesting rusted Marquis wheat at different stages of maturity, at Winnipeg, Man., in 1928.*

Date harvested	Days to maturity when harvested	Weight of 1000 kernels grams	Percentage of green kernels	Weight per measured bushel pounds	Grade
August 23	15	23.62	16	55.7	Feed
August 26	12	27.16	12	57.0	5
August 29	9	28.02	3	59.7	4
September 1	6	32.58	0	59.9	4
September 4	3	35.76	0	60.4	3
September 7	Mature	35.32	0	60.4	3

TABLE 7.—*Effect of harvesting rusted Marquis wheat at different stages of maturity on yield, with the percentage infection of leaf and stem rust, at Winnipeg, in 1929.*

Date harvested	Days to maturity	Stages of maturity of kernels	Per cent leaf rust severity	Per cent stem rust severity	Average yield in grams per rod row	Yield per acre in bushels
August 7	14	thick milk	25	45	109	19.6
August 9	12	very soft dough	25	50	130	23.4
August 11	10	soft dough	30	50	117	21.0
August 13	8	thick dough	35	55	118	21.3
August 15	6	thick dough	35	60	135	24.3
August 17	4	very thick dough	40	65	139	25.1
August 19	2	hard dough	45	70	134	24.1
August 21	Mature	very hard dough	45	70	145	26.2

development from fifteen days to three days early, gave a reduction in kernel weight, and weight per measured bushel, when compared with threshed samples of wheat harvested at the normal time. As the crop was left to mature, there was a gradual and consistent increase in grain weight until the kernels had reached the hard dough stage. A very large number of green kernels were found in the grain harvested fifteen days early. The grain cut September 1 (six days early) was sufficiently far along so that practically all the kernels were normal so far as color was concerned.

The marketable grade of wheat for each date of harvest is given in table 6. Wheat harvested when ripe (September 7), graded 3 Northern. The lowest weight per measured bushel was 55.7 pounds, which was secured on the initial harvest date, (August 23). This grain graded "Feed Wheat". The samples harvested 12, 9, 6, and 3 days before maturity, were of somewhat higher weight per bushel, and the grade was accordingly increased. There can be no doubt that the heavier wheat was of superior market value.

Experiments in 1929

In 1929 two acres of Marquis wheat were used for the date-of-cutting investigation. The wheat was seeded May 19. It was hoped that the late sowing on summer-fallow would afford a rank succulent stand of wheat which would become heavily infected with rust.

The experience gained in 1927 and 1928 indicated that one of the most disconcerting features of rust epidemiology is that every season furnishes a new combination of environmental conditions which, in turn, influences greatly the expression of the disease on the maturing crop. It was thought advisable, therefore, to insure a sufficient amount of rust infection by inducing an artificial epidemic of the disease. In 1929, an epidemic of stem rust was brought about by transplanting from the greenhouses on June 25, at 10 feet intervals in the border rows which surrounded the field, wheat plants which had been previously heavily infected with rust. Primary infections soon appeared in the vicinity of the artificially infected plots and, in a short time, stem rust spots due to secondary infections were established along each side of the field. Although the development and spread of the disease from the various inoculum centres was rather slow during the early part of the season, by July 25, pustules of stem rust could be found on every plant, and from that time the disease spread rapidly. A general light infection of leaf rust was also found by July 25, but owing to the extended drought period the wheat leaves ripened prematurely and the development of the disease was thereby terminated. After August 7 it was difficult to estimate the amount of leaf rust infection.

Plant growth was vigorous and uniform and the wheat was in flower July 17. By July 25, the kernels of the centre spikelets had reached the thin milk stage. On August 5, the grain was in the soft dough stage. The first rows were harvested August 7, fourteen days before the wheat was fully mature, and when the leaves and terminal spikelets had commenced to change color. Thereafter, rod row cuttings were made at two-day intervals until the crop was ripe. After August 11, the drought caused the wheat to ripen quickly and uniformly, and the crop was mature August 21.

TABLE 8.—*Yield per rod row in bushels per acre, of rusted Marquis wheat harvested at different stages of maturity, in 1929.*

Replicates	CUTTINGS								Means of Replicates
	Aug. 7 1	Aug. 9 2	Aug. 11 3	Aug. 13 4	Aug. 15 5	Aug. 17 6	Aug. 19 7	Aug. 21 8	
1	21.4	20.4	25.0	25.4	21.4	28.0	23.8	26.4	23.98
2	18.8	22.6	18.8	16.2	23.8	23.0	24.2	25.3	21.59
3	16.8	21.6	29.6	19.6	26.8	18.8	30.6	30.2	20.90
4	16.4	28.2	14.4	25.0	17.2	20.4	22.2	23.4	24.25
5	13.8	20.2	23.0	20.6	21.0	22.8	42.6	24.2	23.52
6	19.8	27.2	15.0	20.2	19.4	24.6	22.8	35.0	23.00
7	15.4	30.6	13.0	11.6	26.4	31.0	21.6	22.4	21.50
8	23.0	32.4	16.4	33.0	20.0	26.2	32.0	30.0	26.62
9	17.6	21.6	18.0	24.0	21.8	25.0	23.6	28.4	22.50
10	25.8	25.4	21.8	26.2	39.0	17.6	27.8	14.8	24.80
11	19.0	28.6	32.4	29.2	10.8	22.4	26.6	18.8	23.48
12	15.2	32.0	16.2	10.2	33.0	26.6	14.8	16.6	20.58
13	19.4	21.2	18.6	20.4	29.8	17.2	23.6	32.4	22.82
14	24.8	21.0	22.0	24.0	15.6	25.4	23.8	27.2	22.98
15	20.0	24.6	27.2	16.6	24.6	21.4	16.8	22.8	21.75
16	16.6	17.4	19.8	20.6	29.4	26.2	17.0	29.0	22.00
17	22.0	19.6	15.6	21.6	31.6	32.4	17.2	27.4	23.43
18	17.2	14.8	22.6	21.0	22.4	25.4	24.2	23.2	21.35
19	13.4	21.6	17.8	17.8	21.6	27.6	16.0	23.6	19.92
20	20.6	17.2	24.2	12.0	20.4	24.6	21.6	15.2	19.48
21	28.0	23.6	23.8	19.8	30.2	32.8	35.8	28.2	27.77
22	21.6	26.4	27.0	25.0	32.0	38.0	25.0	27.8	27.85
23	22.0	21.4	21.8	22.8	25.0	28.0	29.4	28.8	24.90
24	25.0	26.0	23.0	21.4	22.2	23.6	24.6	43.2	26.12
25	16.4	19.6	18.8	27.2	21.0	18.4	14.2	30.2	20.72
Means of cuttings	19.6	23.41	21.03	21.26	24.26	25.10	24.07	26.18	23.11

General mean = 23.11

Methods of harvesting and threshing were simliar to those used in 1927 and 1928. Percentage of stem rust severity, yield per rod row, weight per 1000 kernels, percentage of shrunken and green kernels, weight per bushel, yield per acre and grade, were ascertained for each date of cutting.

In analyzing the yield data the Analysis of Variance test was used. A complete discussion of the analysis of variance is given by Dr. R. A. Fisher (*11*). In a recent paper Fisher and Wishart (*12*) give full details as to the arithmetical procedure and analysis of Latin Square and Randomized Block experiments. The methods used in analyzing the 1929 yield data are adapted from this paper.

Stage of maturity, percentage severity of leaf and stem rust, yield per rod row, and yield in bushels per acre, of wheat harvested August 7 and thereafter at two-day intervals until August 21 are presented in table 7.

Yield per rod row in bushels per acre of the different cuttings is given in table 8. From this data the means of replicates and cuttings and the sums of squares of replicates, cuttings and error, were calculated. The respective sums of squares and the final analysis of the results are given in the form of a table (table 9).

In this experiment it is necessary to know if the estimate of variance due to time of cutting is significantly greater than that due to error. If there are no date of cutting differences we would expect the variance estimated from the cuttings to differ from that due to error only by an amount which could easily be obtained by chance. As is shown in table 9, the last column gives half the natural logarithm of the estimate of variance in the same line, and is obtained by writing down the common logarithms and multiplying each of these by 1.15129, which is $\frac{1}{2} \log_e 10$. The difference between these half logarithms gives a statistic known as Z. In this experiment $Z = 0.7663$. Entering Fisher's table of Z we find the value of Z at the 1 per cent point = 0.51. Since a Z value of 0.51 gives 100:1 odds, the yield differences of cuttings observed in this experiment are highly significant.

From the analysis of variance table, the standard error of the experiment was calculated directly . Thus in this test the standard error of a single plot is the square root of the error estimate of variance:

$$\text{Standard Error} = \sqrt{\frac{4636.43}{168}} = 27.60$$

Expressed as standard error by means of cuttings,

$$\text{Standard Error} = \frac{\sqrt{27.60}}{\sqrt{25}} = \frac{5.2536}{5} = 1.0507$$

In comparing the yield differences observed between cuttings, differences as great or greater than three times the standard error ($1.0507 \times 3 = 3.15$) were considered significant.

From table 7 it is apparent that harvesting rusted wheat fourteen days before it was fully matured resulted in a loss in yield of 6.6 bushels per

TABLE 9.– *Analysis of variance. Yield data of rod rows of rusted Marquis wheat harvested at different stages of maturity, at Winnipeg, in 1929.*

	Sums of squares	Degrees of freedom	Estimate of variance	½ Natural Log
Replicates	1011.43	24	42.14	
Cuttings	894.30	7	127.76	2.4252
Remainder	4636.43	168	27.60	1.6589
Total	6542.16	199		Z = .7663

5% point = .3706 1% point = .5152

TABLE 10.—*Percentage of green and shrunken kernels, weight per 1000 kernels, weight per bushel, and grade, of rusted Marquis wheat harvested at different stages of maturity, in 1929.*

Date harvested	Days to maturity	Percentage of green kernels	Percentage of shrunken kernels	Weight per 1000 kernels	Weight per measured bushel	Grade
August 7	14	12.8	92.8	19.3	54	5
August 9	12	9.8	92.0	21.2	56	4
August 11	10	7.6	90.1	20.9	56.2	4
August 13	8	9.0	86.4	21.7	56.5	4
August 15	6	6.6	84.3	22.6	57	3
August 17	4	4.7	80.5	22.9	57.5	3
August 19	2	3.8	85.0	23.4	58	2
August 21	mature	2.4	72.2	24.2	59	2

acre. Since this difference is more than six times the standard error the chances that it is significant are indeed very great.

The difference observed between wheat cut twelve days early and at maturity, is barely significant. There is however, a statistically significant difference in yield when rusted wheat cut ten and eight days early was compared with the mature cutting. In each case the difference was more than four times the standard error. Although a reduction of 1.9 bushels per acre occurred when wheat was harvested six days early, the result is not statistically important. The low yield observed four days before maturity is believed to be due to an error in determination for it does not approach the general upward trend of yields. In the case of the cutting made only two days early the reduced yield difference of 2.1 bushels per acre is only twice as great as the standard error and is not statistically significant.

In spite of fluctuations, it is evident that there is a gradual increase in yield until maturity. Although in some cases differences were not great enough to establish statistical significance there can be little doubt of the significance of the general upward trend of yields towards maturity.

The results presented in table 10 convincingly demonstrate that the quality of grain from a heavily rusted crop was not improved by premature harvesting. On the other hand, it is distinctly evident that quality, as indicated by weight per bushel, and color and plumpness of kernel, was markedly improved by allowing the wheat to approach maturity before harvesting. The high percentage of badly shrunken kernels found in grain harvested at maturity (August 21) is indicative of the damage caused by rust at Winnipeg, in 1929.

In general, the 1929 results confirm the findings of 1927 and 1928, and indicate clearly that nothing was gained by prematurely harvesting rusted wheat.

Severity of Rust Epidemic in 1929

In 1929 under an artificially induced rust epidemic, an experiment was made also to determine the amount of injury caused by stem rust. Marquis wheat was grown in plots adjoining the series of plots used for the date-of-cutting experiments. One group of six plots was dusted bi-weekly with Kolodust at the rate of 30 pounds per acre per application for a period of five weeks, July 15-August 18. The control series of plots consist of six undusted plots. Each series was harvested when the crop had reached full maturity. The dusting treatment effectively controlled stem rust at Winnipeg in 1929. The amounts of stem and leaf rust infection on dusted and undusted Marquis wheat at different stages of growth, are shown in figures 1 and 2.

The data summarized in table 11, in which the yield and quality of the grain from dusted and non-dusted plots are directly compared, give a fair indication of the actual amount of damage caused by rust. The stem rust epidemic reduced the yield nine bushels per acre and lowered the grade from 1 Northern to 2 Northern. The reduction in weight per measured bushel and the high percentage of shrunken wheat kernels of the non-dusted Marquis wheat furnishes direct evidence of the extent of rust injury.

TABLE 11.—*The effect on yield and quality of harvesting mature rusted and non-rusted Marquis wheat at Winnipeg, in 1929.*

Treatment	Per cent severity of stem rust	Percentage of badly shrunken kernels	Percentage of green kernels	Weight per 1000 kernels grams	Weight per bushel pounds	Yield per acre bushels	Grade
Rusted, non-dusted harvested August 21	70	72.2	2.4	24.28	59	26.2	2
Non-rusted, dusted with sulphur, harvested August 21	trace	8.1	.4	36.08	65	35.2	1

TABLE 12.—*Summary of three years results. The effect of harvesting Marquis wheat grown under rust epidemic conditions, at different stages of maturity, on the yield and quality, in 1927, 1928, and 1929, at Winnipeg, Manitoba.*

Year	1927				1928				1929			
Days to maturity when harvested	Per cent stem rust severity	Weight per bushel pounds	Yield per acre bushels	Grade	Per cent stem rust severity	Weight per bushel pounds	Yield per acre bushels	Grade	Per cent stem rust severity	Weight per bushel pounds	Yield per acre bushels	Grade
12	75	43.1	12.6	Feed	20	57.0	22.3	4	50	56.0	23.4	4
10	—	—	—	—	—	—	—	—	50	56.2	21.0	4
9	—	—	—	—	25	59.7	23.7	3	—	—	—	—
8	—	—	—	—	—	—	—	—	55	56.5	21.3	4
6	75	49.3	12.4	Feed	40	59.9	23.8	3	60	57.0	24.3	3
4	—	—	—	—	—	—	—	—	65	57.7	25.1	3
3	—	—	—	—	55	60.2	27.0	2	—	—	—	—
2	—	—	—	—	—	—	—	—	70	58.0	24.1	2
Mature	85	54.1	13.2	6	55	60.4	28.5	2	70	59.0	26.2	2

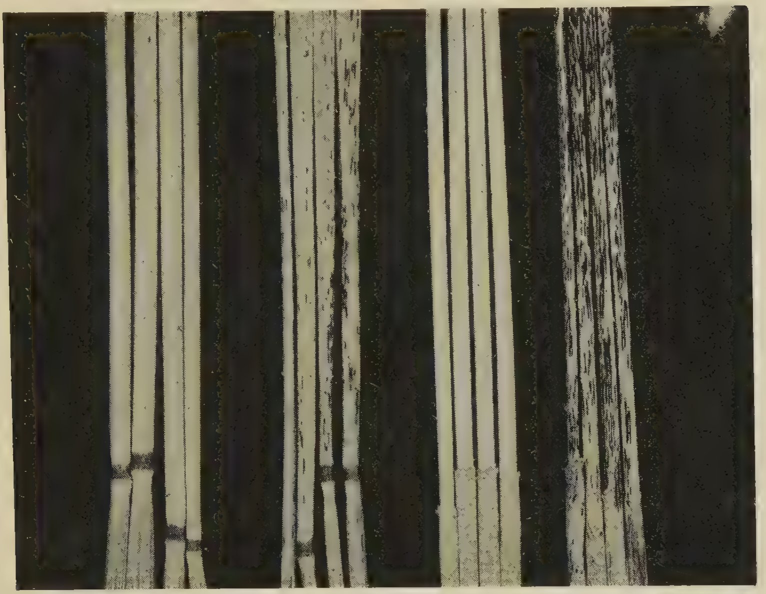

Figure 1. Stems of Marquis wheat grown at Winnipeg, 1929, showing different amounts of stem rust infection at different growth stages.

Left to right—Non-rusted wheat, August 7; rusted wheat (45 per cent), August 7; non-rusted wheat, August 20; rusted wheat (80 per cent), August 20.

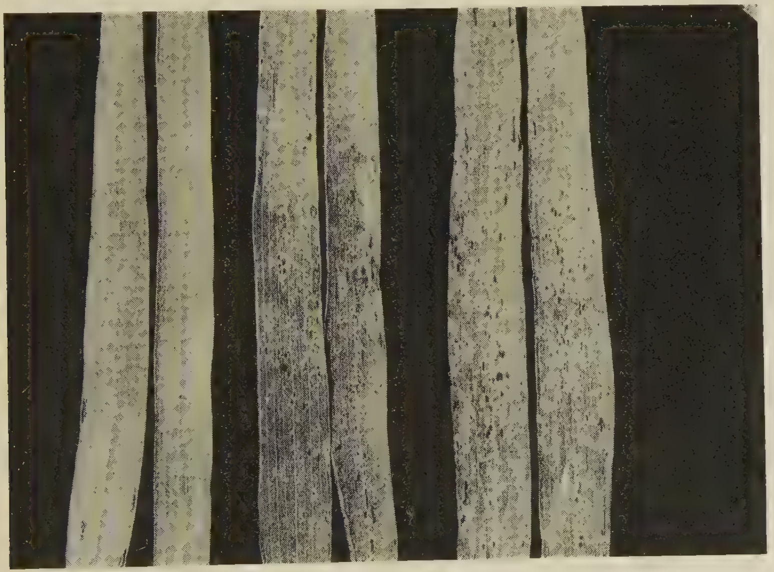

Figure 2. Leaves of Marquis wheat grown at Winnipeg, 1929, showing different amounts of leaf rust.

Left to right—Non-rusted leaves, August 20; rusted leaves (20 per cent), August 7; rusted leaves (45 per cent), August 20.

Summary and Conclusions

Field experiments were made in Manitoba in 1927, 1928 and 1929, to determine the effect on the yield and quality of harvesting rusted Marquis wheat at different stages of maturity. An attempt was made also to discover if there were any indications that food materials stored temporarily in the stems and leaves were translocated to any appreciable extent to the kernels when such wheat was cut at different stages of maturity and cured under normal harvest conditions.

In 1927, under conditions of a severe natural epidemic of leaf and of stem rust, Marquis wheat was harvested 18, 12, and 6 days before, and at maturity, in the districts of Morden, Thornhill, Graysville and Winnipeg. At Winnipeg in 1928, a diseased crop was cut at the following stages: 12, 9, 6 and 3 days before, and at maturity. In 1929, under an artificially induced epidemic of stem rust cuttings of rusted wheat were made at intervals of two days, beginning on August 7 and ending at maturity (August 21). In each year, the yield data were studied statistically and the weight per bushel, 1000-kernel weight, percentage of green kernels, and grade, were determined for each date of cutting. The yield and grade results obtained in Manitoba in 1927, 1928, and 1929, are summarized in table 12.

In each year cutting rusted wheat before it was fully mature significantly reduced the yield. Grain quality, as indicated by weight per bushel and 1000-kernel weight, was markedly improved when the plants were permitted to mature before harvesting, while the percentage of green and shrunken kernels was reduced. From the kernel weight results it is apparent that little or no filling of the grain occurred after cutting. In 1927 and 1929 particularly, stem rust developed rapidly and its destructiveness increased as the wheat approached maturity. Under these conditions, yield and quality of wheat harvested prematurely were significantly less than the yield and quality of the more heavily rusted wheat harvested at the normal time.

The results obtained in 1929 on sulphur dusted plots distinctly show that rust is an important factor in reducing yield and lowering the grade. Harvesting wheat on the "green side" to avoid hail and frost injury is a justifiable practise, but from the results of this investigation it would seem that there is nothing to recommend the practise of cutting wheat early to avoid rust damage. The results show that, in order to secure the largest yield and the best quality of grain, heavily rusted wheat should be harvested when the majority of the kernels are in the hard dough stage, that is, two or three days before it is fully mature.

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STUDIES OF THE EFFECTS OF OTHER SOIL-INHABITING MICRO-ORGANISMS ON THE VIRULENCE OF *OPHIOBOLUS GRAMINIS* SACC.*

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Introduction

There is nothing really new in the fact that fungi and bacteria in general exhibit varying degrees of compatibility or even extreme antibiotic relationships in artificial culture. That they actually do this in a soil habitat has also been recognized, but it is not yet clear to what extent they demonstrate these qualities in the soil. There are, obviously, many difficulties in determining these relationships under natural soil conditions, mainly because of a lack of reliable criteria. Plate counts from the soil give only a hazy and often incomplete picture of conditions, particularly with regard to the many soil-inhabiting fungi which produce few or no spores. Waksman (*11*), a widely recognized authority on soil micro-biology, has pointed out the necessity for more investigation on the behaviour of the soil micro-organisms in association in the soil. However, plant pathologists concerned with diseases caused by soil inhabiting micro-organisms must learn more about the environmental conditions affecting the pathogenes which they are studying. It is at least a reasonable supposition that the micro-flora of the soil are profoundly affected by various crops, cultural practices and climatic factors. More adequate knowledge of the effect of these factors would materially assist in a better understanding of soil-borne plant diseases and their control.

For some time, in our studies at this laboratory, it has been known that the effectiveness of the inocula of the various root-rotting pathogenes of the cereal crops became vitiated soon after being added to the soil. This happens in field or in greenhouse culture, notwithstanding the liberal amount of inoculum that may be applied. Sanford and Broadfoot (*7*) called attention to this in connection with root rot studies in 1930. Perhaps the most plausible explanation of the decrease in the efficiency of the inoculum is that other soil inhabiting organisms, both fauna and flora, exhibit varying degrees of antibiosis or compatibility toward the newly introduced pathogenes and produce a state which largely controls the effectiveness of the inocula.

Broadfoot (*2*) established the fact that, in greenhouse culture, the inoculum of *Ophiobolus graminis*, which had destroyed the first planting of wheat, was apparently wholly ineffective after 120 days, on the second planting. It was also shown that the infection rating was higher in the sterilized than in the non-sterilized soil.

The suppressive effect of one organism on another in artificial culture has been cited by several workers. Sanford (*6*) in studying the potato scab disease at the University of Minnesota, 1922-25, observed that, whenever control is obtained by adding green rye to the soil, it must come by other

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soil micro-organisms inhibiting the activity of *Actinomyces scabies.* In the same study a large number of bacteria were isolated from the soil and their effect on the scab organism studied. Various degrees of compatibility and toxicity were observed and the suggestion made that a similar phenomenon probably existed naturally in the soil and therefore was of significance in the potato scab problem. Later, Millard and Taylor (*4*) observed that *A. praecox* suppressed the activity of *A. scabies* in scab formation on potatoes in grass-soil culture. Bamberg (*1*) found that a certain culture of bacteria, isolated from corn, prevented infection of *Zea mays* by *Ustilago Zeae* and even destroyed colonies of this smut fungus on artificial media. Porter (*5*) reported that a certain soil-inhabiting bacterium protected the flax plant from attack by *Fusarium Lini.* Vasudeva (*10*) found that a filtrate of *Botrytis Allii* suppressed the pathogenicity of *Monilia fructigena* in causing decay of apples. Henry (*3*), working with 7 cultures of soil micro-organisms, found that the pathogenicity of *Helminthosporium sativum* on wheat seedlings cultured in sterile soil, was suppressed slightly by 2 cultures of actinomycetes, Nos. 1 and 2, and but slightly more by 2 cultures of different bacteria, Nos. 5 and 6. He found that the pathogenicity of *H. sativum* was suppressed much more by a combination of 4 cultures of fungi, (a Rhizopus, a Penicillium, a Fusarium and an unknown fungus, Nos. 3, 4, 7 and 8, respectively) and again, still slightly more, when these fungi were associated with the actinomycetes and bacteria. None of these cultures were studied singly, but in groups as named, or in association of groups.

A note by the authors (*8*) in the March, 1931 issue of *Scientific Agriculture* entitled, "Biological control of the root rots of cereals" refers to the results reported herein.

Experimental Methods

In order to study the effect of other soil-inhabiting micro-organisms on the fungi causing root rots of cereal crops, some sixty-six isolations of fungi and bacteria were obtained by the usual methods. Most of these were taken directly from the soil, or isolated from the roots and culms of wheat. A few identified cultures of soil-inhabiting bacteria were supplied by the University Departments of Dairy Bacteriology and Medical Bacteriology. The cultures employed are listed in table 1.

For the "living culture" tests, the fungi were grown on an oat-hull substrate, while the bacterial isolations were increased on potato dextrose decoction, adjusted to a pH value of 6.7. For the "filtrate" tests, the potato dextrose decoction was used to increase both bacteria and fungi. The inoculum of *O. graminis,* used throughout the experiment, was also grown on an oat-hull substrate. All the cultures of fungi, including *O. graminis,* were allowed to age thirty days before being used. All bacterial cultures were incubated two weeks prior to being used, either for the "living cultures" test or for the "filtrate". The filtrates were obtained in the usual manner by passing the various broth cultures through Berkefeld filters. For each pot of the filtrate test, a 10-cc portion of the filtrate was used to moisten the 10-gr. portion of oat hull inoculum (*O. graminis*) or the 10 grams of sterile oat hulls in the check pots. In the "living culture" tests, 8-cc amounts of the bacterial broths were applied to the inoculated oat-hull substrate in the same

TABLE 1.—*The cultures of micro-organisms used in the experiment to study the association effects of soil micro-organisms on the pathogenicity of Ophiobolus graminis on wheat seedlings.*

No.	Organism	Source
1	*Helminthosporium sativum*	Camrose, Alta., wheat root
2	*Fusarium culmorum*	" " " "
3	*Wojnowicia graminis*	Cowley, Alta., wheat culm
4	*Leptosphaeria herpotrichoides*	Baarn, Holland
5	*Sclerotinia* sp.	Edmonton, Alta., sweet clover root
6	*Fusarium culmorum*	Davenport, Wash., wheat root
7	*Ascochyta graminicola*	Cowley, Alta., wheat culm
8	Bacteria—unidentified	Edmonton, Alta., soil
9	Fungus—unidentified	Lacombe, Alta., wheat root
10	*Plenodomus Meliloti*	Saskatoon, Sask., sweet clover root
11	*Helminthosporium sativum*	Winnipeg, Man., (F. J. Greaney)
12	*Rhizoctonia* sp.	Edmonton, Alta., potato
13	*Actinomyces* sp.	Indian Head, Sask., wheat root
14	*Bacterium transluscens* var. *undulosum*	Washington, D.C., (Charlotte Elliott)
16	Fungus—unidentified	Beaverlodge, Alta., alfalfa root
17	" "	Kentville, N.S. " "
18	*Typhula graminum*	Baarn, Holland
19	Bacillus—unidentified	Edmonton, Alta., potato
20	" "	" " spinach
21	Bacterium "	" " potato
22	" "	" " sweet potato
23	*Plenodomus destruens*	Florida (L. L. Harter)
24	" *chelidanii*	Baarn, Holland
25	Fungus—unidentified	Edmonton, Alta., potato
26	" "	Beaverlodge, Alta., lawn grass
27	" "	Rosevear, Alta., potato
28	*Actinomyces* sp.	Edmonton, Alta., potato
29	Bacteria—unidentified	" " soil
30	" "	" " "
31	" "	" " "
32	*Actinomyces* sp.	Edmonton, Alta., potato
33	Bacteria—unidentified	Edmonton, Alta., soil
34	" "	" " "
35	" "	" " "
36	" "	" " "
37	" "	" " "
38	" "	" " "
39	" "	" " "
40	" "	" " "
41	" "	" " "
42	" "	" " "
43	" "	" " "
44	" "	" " "
45	" "	" " "
46	*Ophiobolus graminis*	Saskatchewan, wheat culm
47	Bacteria—unidentified	Edmonton, Alta., soil
48	*Bacillus fecalis* var. *alcaligines*	Univ. of Alta., (R. M. Shaw)
49	*Botrytis cinerea*	Washington, D.C., (J. L. Lauritzen)
50	*Bacillus coli*	Univ. of Alta., (H. R. Thornton)
51	" *butyricum*	" " " "
52	" *cinnebareus*	" " " "
53	" *cereus*	" " " "
54	*Bacterium anthracoides*	" " " "
55	*Bacillus mycoides*	" " " "
56	" *megaterium*	" " " "
57	" *subtilis*	" " " "
58	" *vulgatus*	" " " "
59	" *ramosus*	" " " "
60	" strong alkali producer	" " " "
61	" " " "	" " " "
62	*Penicillium* sp.	" " " wheat root
63	*Rhizopus* sp.	" " " " "
64	Bacteria—unidentified	" " " soil
65	" "	Morden, Man., wheat root
66	" "	Edmonton, Alta., soil
67	" "	" " "

manner as in the case of the filtrates, while for the fungi, a 10-gr. portion was mixed with an equal amount of the oat hull inoculum of *O. graminis*. All the combinations of *O. graminis* inoculum with the living culture or the filtrates were placed directly over the uncovered wheat grains at seed level. Following this, the seed and the various treatments were covered with sterilized soil to a depth of one inch.

It will be observed that the organisms were not increased on a sterile soil. There did not seem to be any particular reason for doing this, because the nutrients required would be provided equally well from the sterilized Edmonton black loam or from the artificial oat-hull media used.

The experiment was made in pot culture under greenhouse conditions, where a constant soil temperature of about 20° C. was maintained. The soil consisted of three parts of black Edmonton loam, and one part of plaster sand. This was sterilized under steam pressure, in the pots. Soil moisture was kept as near optimum as possible. The final notes on the results were taken 22 days after planting, and expressed numerically for each plant.

The general arrangement of the experiment was as follows: living culture plus *O. graminis* (3 pots per culture); living culture plus sterile oat hulls (3 pots per culture); filtrate plus *O. graminis* (3 pots per filtrate); filtrate plus sterile oat hulls (3 pots per filtrate); sterile oat hulls alone (12 pots); sterile soil alone (12 pots); *O. graminis* alone (42 pots). The 832 pots for the entire experiment were systematically distributed as indicated in table 2.

Experimental Results

The illustrations in plates I and II are intended to present in a general way the types of control, or the lack of it, obtained by the use of the various cultures, or filtrates of these cultures, in association with *O. graminis*. These effects on the plants were apparent 21 days after planting and before the infection rating on their roots had been taken. As would be expected, the final infection ratings on the plants, represented by the various lots in the pots, did not always bear out external appearances. In fact it became clear that infection ratings which would tell the final result could not be made until the seedlings were considerably older than they were.

In plate I, figures (A), (B), (C) and (D) show the various types of "no-control" obtained from some of the living cultures or their filtrates. The pots in the front row in each figure contain the inoculum of *O. graminis* treated with a living culture or filtrate, while the corresponding pots in the back rows contain only the culture or filtrate treatment. The front rows of figures (A) and (B) represent the various types of "no-control" resulting from the filtrate treatment of different fungi and bacteria, respectively. Likewise various types of the pots in the front rows of figures (C) and (D) illustrate the types of "no-control" derived from living cultures of fungi and bacteria, respectively. It is apparent that there has been in general less control from these filtrates than from the corresponding living cultures. This difference was fairly constant throughout the experiment. Also, none of the filtrates show any deleterious effects on the seedlings.

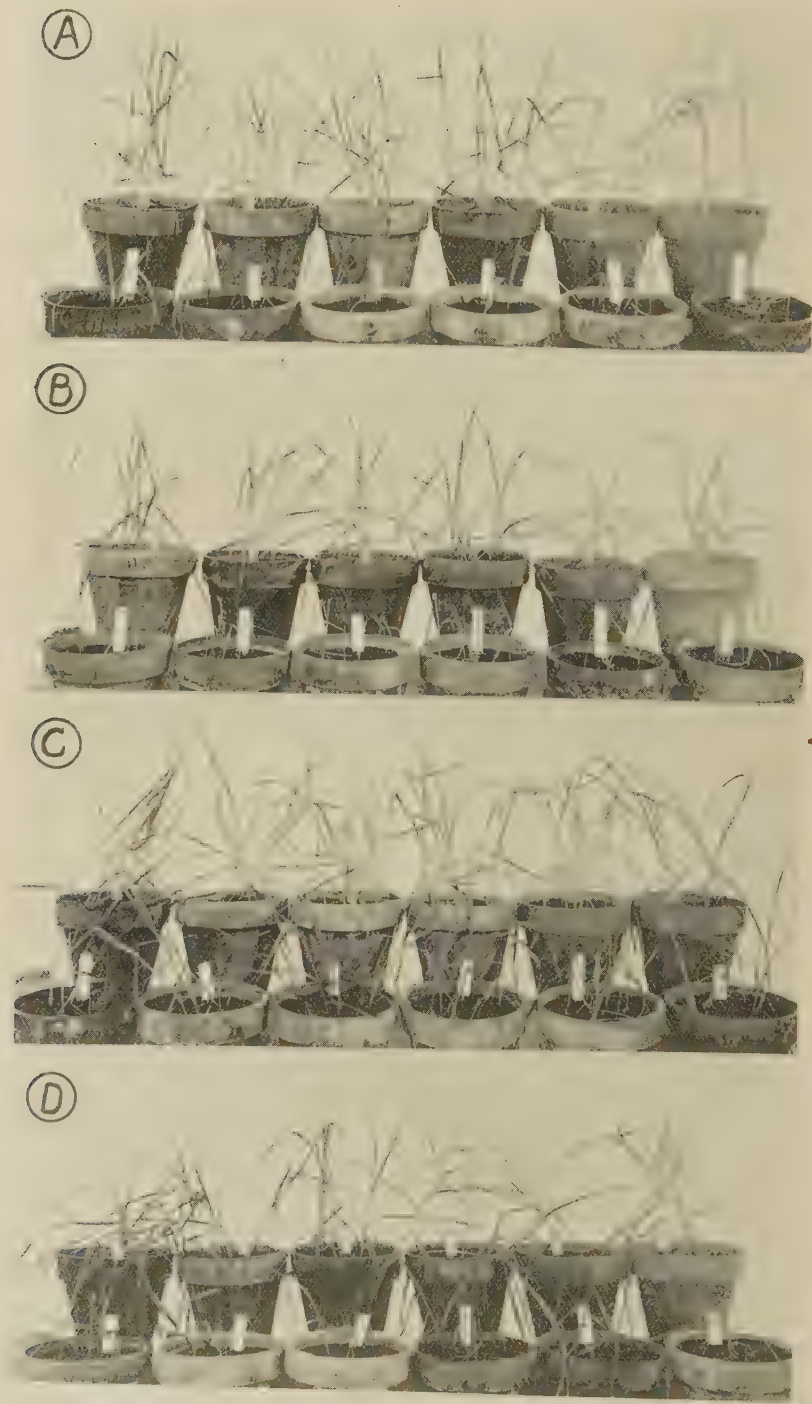

Plate I.

(See footnote on opposite page for explanation).

Coming to plate II, we see the types of control obtained by the use of certain other cultures and their filtrates. The inoculum of *O. graminis* is present, with the other treatments, in the pots of all figures of this plate. The types of control resulting from the use of the filtrates of the fungi and bacteria are depicted in figures (A) and (B), respectively. Figures (C) and (D), on the other hand, illustrate the measure of protection afforded by the corresponding living cultures of fungi and bacteria, respectively.

In plate II, figure (E), the pot on the left represents the extreme degree of injury which resulted from *O. graminis* without the addition of a filtrate or culture treatment. Therefore, it serves as a basis for comparison of all treatments throughout the experiment. The next pot represents the degree of injury resulting from the pathogene plus its own filtrate. In the third pot, which received only the filtrate of the pathogene, the plants are all normal, although some unfortunately are leaning against the neighbouring pot. The second pot on the right contains sterilized soil with no additional treatment. The pot on the right had oat hulls added to the soil, but no pathogene. These last two pots represent the types of growth in the soil check pots, and the oat hull check pots, respectively, the data of which are contained in table 2 and figure 2.

In several cases the filtrate treatment gave greater protection from the pathogene than the corresponding culture did, while in some other instances the reverse of this occurred. In figure I, (A), the filtrate from culture No. 62 (Penicillium), gave good control while the culture gave only a low degree of intermediate control. In figure I, (B) the filtrate from bacterial culture No. 47 gave slight intermediate control, while the culture gave good protection. These differences are fairly well illustrated here.

In table 2, more complete data regarding the suppressive effect on *O. graminis* exercised by the various cultures and their filtrates are presented in replicates "A", "B", and "C" of the culture treatments, and "D", "E", and "F" of the filtrate treatments. The height of the plants, the infection rating, and the classes into which the reaction "R" falls, are given. These are arranged for each case and a final control class made for each culture. Also the average height of the plants and the average infection rating are given for each culture or filtrate, when used with or without the pathogene. The hydrogen-ion concentrations of the various filtrates are also included.

Upon a close examination of the data in table 2, one finds that the infection rating may often vary considerably in the different replicates, a fact which has made it necessary to present the results in greater detail than otherwise would have been necessary. At present we are unable to offer an explanation for these variations, except that possibly the growth of certain other protective or non-protective organisms may have interferred with

Plate I. Illustrates the lack of control of *Ophiobolus graminis* by certain fungi and bacteria and their corresponding filtrates. Pots in front rows contain *O. graminis* plus treatment; pots in back rows contain treatment without pathogene.

A. Filtrates from fungi.

B. Filtrates from bacteria.

C. Cultures of fungi.

D. Cultures of bacteria.

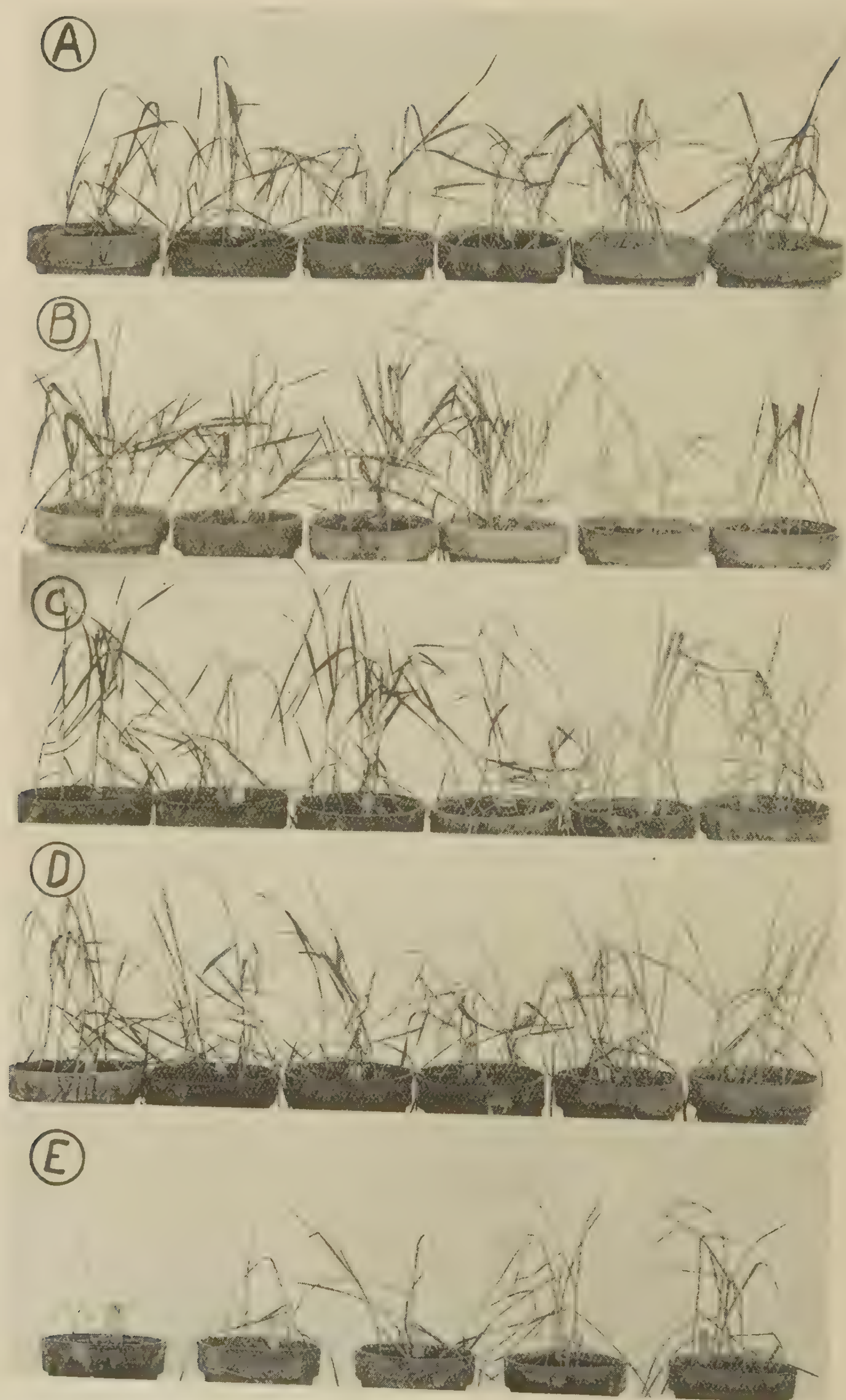

Plate II.

(See footnote on opposite page for explanation).

the normal result of the treatments applied. The infection ratings and class groupings are made with sufficient rigor to give a definite value to the classes, so that any treatment which falls into the intermediate control class or the control class is outstanding in its protective effect. It is also felt that the plants in these classes would have reached maturity in a reasonably healthy condition, especially those in the control class "C".

Any treatments that gave an infection rating of 10 per cent or less were placed in the control class. Those with an infection rating above 10 per cent or below 20 per cent fell in to the intermediate control class. The treatments which permitted a higher infection rating than 30 per cent were placed in the "no-control" class. Under this classification 6 cultures of fungi and 15 cultures of bacteria gave "control"; 7 cultures of fungi and 8 cultures of bacteria gave "intermediate control"; while 13 cultures of fungi and 17 cultures of bacteria fell into the "no-control" class.

The results from the filtrate treatments are listed on the right hand side of table 2. Of the 26 filtrates from fungi, 2 gave "control", while 1 gave "intermediate control". The remainder, 23 in number, fell into the "no-control" class, of which 3 intensified the damage. Of the 40 filtrates from the bacteria, 6 gave "control", 1 gave "intermediate control" and 33 gave "no-control", of which 6 intensified the injury.

An examination of the hydrogen-ion concentration data of the filtrates listed in table 2 indicates that the suppressive effect of the filtrates was exercised without regard to the reaction of the filtrates, for this happened in filtrates Nos. 20, 32, 62, 21, 22, 33, 39, and 45, of which the pH values were 7.3, 5.8, 5.5, 5.7, 4.3, 5.2, 6.5, and 7.0, respectively. On the other hand, many filtrates which were decidedly acid gave no control. Judging from the tests which were made, it would appear that the effect of the reaction of the filtrate on the soil would be transitory only. The marked buffer action of the soil used, and its initial reaction of pH 6.3, would tend rather quickly to neutralize the acid or the alkali of the filtrate toward the initial reaction of the soil itself. A proportional amount of the soil used to cover the seed was used on three different filtrates representing the extreme range of acidity or alkalinity shown by the filtrate. The resulting reaction of the soil, the hydrogen-ion concentration of the filtrate, and the initial reaction of the soil are listed in table 3.

From the data shown, it would appear that the soil had been successful in rather quickly adjusting the reaction of the filtrate towards its own initial reaction. Therefore, it is thought that the initial reaction of the filtrate did not play an important role in the final effect of the filtrate treatment.

Plate II. Illustrates various degrees of control of *Ophiobolus graminis* by certain fungi and bacteria and their corresponding filtrates.

A. Filtrates from fungi.
B. Filtrates from bacteria.
C. Cultures of fungi.
D. Cultures of bacteria.
E. Left to right: *O. graminis,* alone; pathogene plus its filtrate; filtrate of pathogene, alone; no pathogene or treatment; treatment of 10 grams of oat hulls, alone.

TABLE 2.—*The effect of bacteria and fungi (culture or its filtrate) on the pathogenicity of* Ophiobolus graminis *on Marquis wheat seedlings.*

Oph. gr. + Culture No.	Culture treatments on *Ophiobolus graminis*														Filtrate treatments on *Ophiobolus graminis*														pH
	Replicate												Cult. only Average		Replicate												Filt. only Average		
	A			B			C			Average					D			E			F			Average					
	Ht	IR	R	Ht	IR	R	Ht	IR	R	Ht	IR	R	Ht	IR	Ht	IR	R	Ht	IR	R	Ht	IR	R	Ht	IR	R	Ht	IR	
1	30.0	33.0	NC	29.0	35.8	NC	29.8	37.0	NC	29.6	35.3	NC	37.9	13.3	29.0	28.3	NC	23.0	56.7	NC	25.8	48.3	NC	29.3	44.4	NC	40.1	0.2	6.7
2	34.7	6.0	C	30.2	45.0	NC	29.0	43.3	NC	31.3	31.4	NC	37.7	5.3	24.8	43.3	NC	17.2	60.0	NC	25.0	5.0	C	22.3	36.1	NC	23.8	25.7	5.6
3	35.4	6.0	C	37.0	7.5	C	39.0	0.8	C	37.1	4.8	C	36.6	8.8	28.0	27.5	NC	40.0	53.3	NC	25.0	26.7	NC	31.0	35.8	NC	34.5	1.7	6.6
4	28.2	10.8	IC	38.5	13.3	IC	40.2	3.3	C	35.6	11.6	IC	36.3	7.2	22.2	12.5	IC	19.3	46.7	NC	23.7	40.0	NC	21.7	36.4	NC	38.2	1.1	6.1
5	37.7	0.8	C	32.8	21.8	NC	31.5	54.2	NC	33.4	23.3	NC	35.8	2.5	17.7	46.7	NC	22.2	40.0	NC	21.5	40.0	NC	20.5	42.2	NC	39.5	2.2	5.0
6	32.0	11.7	IC	38.2	1.7	C	32.0	33.3	NC	34.1	15.6	IC	38.8	5.0	19.3	45.0	NC	21.5	45.8	NC	26.3	33.3	NC	22.4	41.4	NC	26.8	15.6	6.0
7	31.0	54.2	NC	36.5	13.3	IC	30.2	33.0	NC	32.6	33.5	NC	37.0	3.9	18.8	50.0	NC	19.8	50.0	NC	20.3	41.7	NC	19.6	49.2	NC	36.5	0.0	6.7
8	34.0	15.0	IC	33.2	7.5	C	30.6	44.0	NC	32.6	22.2	NC	36.4	2.0	25.8	24.2	NC	28.2	26.3	NC	23.5	48.3	NC	25.8	32.9	NC	37.1	0.0	7.3
9	36.0	35.0	NC	37.5	33.0	NC	33.5	29.2	NC	35.7	32.5	NC	34.5	33.6	18.5	40.0	NC	18.3	50.0	NC	21.8	46.7	NC	19.5	45.6	NC	36.9	0.0	6.8
o-ck	31.8	50.8		34.0	36.7		30.3	43.3		32.0	43.6				23.3	58.3		23.0	48.3		18.8	41.7		21.7	49.4				
10	35.2	9.2	C	39.8	5.8	C	33.5	5.8	C	36.2	6.9	C	36.8	2.5															
11	31.7	25.0	NC	39.8	1.7	C	35.2	8.0	C	35.6	11.6	C?	37.7	14.4	19.5	86.0	NC	31.0	28.3	NC	30.2	22.5	NC	26.9	45.6	NC	37.6	1.1	7.0
12	36.5	38.3	NC	38.0	17.5	IC	24.2	26.7	NC	32.9	27.5	NC	40.1	1.1	17.8	53.3	NC	19.5	51.7	NC	24.8	46.7	NC	20.7	50.6	NC	37.7	0.0	6.7
13	36.6	20.0	IC	39.0	5.8	C	32.5	25.0	NC	33.0	16.9	IC	37.2	2.5	19.3	61.7	NC	21.5	48.3	NC	23.2	33.3	NC	21.3	47.8	NC	37.0	1.3	6.3
14	36.0	5.0	C	37.8	0.8	C	33.7	3.5	C	35.8	3.1	C	37.9	1.8	17.3	70.0	NC	21.0	51.7	NC	25.7	41.7	NC	21.3	54.5	NC	37.2	0.0	8.4
s-ck	37.7	0.0		41.0	0.0		37.1	0.0		38.5	0.0				35.0	0.0		38.8	0.0		36.0	0.0		36.6	0.0				
oh-ck	36.5	0.0		37.7	0.0		35.5	4.2		36.6	1.4				38.5	0.0		36.0	0.0		35.2	0.0		36.6	0.0				
16	38.3	20.0	IC	36.8	8.3	C	33.2	15.0	IC	36.1	14.4	IC	37.1	3.9	26.5	20.0	IC	23.2	33.3	NC	32.3	2.5	C	27.3	18.6	IC	37.2	1.1	6.0
17	38.0	16.7	IC	25.0	28.3	NC	32.2	6.6	C	31.7	17.2	IC	34.9	4.7	19.2	48.3	NC	23.2	32.5	NC	21.5	40.0	NC	21.3	40.3	NC	38.0	0.0	5.3
18	29.8	14.2	IC	39.3	9.2	C	28.7	15.0	IC	32.6	12.8	IC	36.4	4.2	19.3	26.7	NC	19.8	39.2	NC	23.2	36.7	NC	20.8	34.5	NC	37.5	0.7	6.7
o-ck	32.0	33.3		34.0	40.8		33.8	25.6		33.3	33.2				26.0	60.0		30.2	35.0		28.2	26.7		28.1	40.6				
19	38.0	10.0	C	40.5	0.0	C	32.0	18.3	IC	36.8	9.4	C	39.1	0.0	33.0	5.0	C	29.0	33.3	NC	25.0	25.0	NC	29.0	20.4	NC	36.9	0.6	7.2
20	32.8	10.0	C	39.8	1.7	C	26.7	17.5	IC	33.1	9.7	C	39.6	0.0	37.0	8.3	C	31.0	3.3	C	38.0	0.8	C	35.3	4.1	C	38.2	0.0	7.3
21	34.5	23.3	NC	38.0	2.5	C	24.5	22.5	NC	32.3	16.1	NC?	37.7	0.8	36.8	3.3	C	22.3	41.7	NC	37.2	4.2	C	32.1	16.4	C?	36.3	0.0	5.7
22	26.2	15.0	IC	39.2	3.3	C	38.6	3.3	C	34.7	7.2	C	38.3	1.6	38.0	1.7	C	35.8	0.0	C	28.7	31.7	NC	34.2	11.1	C?	37.5	0.0	4.3
23	30.7	27.5	NC	40.2	23.3	NC	22.2	39.2	NC	32.7	30.0	NC	37.3	2.5	19.5	61.7	NC	20.2	11.7	IC	20.8	50.0	NC	20.2	41.1	NC	38.3	0.0	6.3
24	33.0	5.5	C	36.7	5.6	C	24.0	18.3	IC	31.2	9.8	C	34.3	3.7	29.4	23.3	NC	38.3	33.3	NC	28.7	28.2	NC	28.8	28.3	NC	38.8	0.0	6.4
25	34.0	30.0	NC	36.8	32.5	NC	25.5	26.7	NC	32.1	29.7	NC	39.7	2.8	31.2	18.3	IC	37.2	21.7	NC	18.0	49.2	NC	28.8	29.7	NC	36.9	2.2	7.0
26	36.5	17.5	IC	40.2	1.7	C	38.0	0.8	C	38.2	6.8	C	40.3	0.5	20.5	60.0	NC	22.8	31.7	NC	19.7	41.7	NC	21.0	44.5	NC	35.9	3.1	6.4
27	36.6	11.7	IC	37.7	35.0	NC	35.8	21.7	NC	36.7	22.8	NC	37.5	0.3	19.5	75.0	NC	15.7	33.3	NC	20.2	41.7	NC	18.5	50.0	NC	34.8	0.0	5.3
o-ck	19.8	50.0		37.3	25.0		33.8	21.7		30.3	32.2				27.8	58.3		24.8	30.0		23.7	41.7		25.4	40.0				
28	24.8	37.5	NC	36.5	2.5	C	28.3	38.3	NC	29.9	26.1	NC	35.9	0.3	30.5	40.0	NC	31.8	25.0	NC	19.5	38.3	NC	27.3	34.4	NC	39.3	1.4	7.3
29	33.5	31.7	NC	36.5	0.8	C	28.0	16.7	IC	32.7	16.4	IC	39.9	0.3	18.2	53.3	NC	19.8	46.0	NC	29.7	15.8	IC	22.6	38.4	NC	36.5	2.2	5.6
30	34.3	17.5	IC	41.3	0.0	C	32.7	3.3	C	36.1	3.6	C	39.9	0.0	17.5	41.3	NC	16.8	41.7	NC	25.3	46.7	NC	19.9	43.2	NC	36.3	1.1	7.2
31	27.2	40.0	NC	36.2	16.7	IC	25.7	59.2	NC	29.7	38.6	NC	37.9	0.3	24.5	56.7	NC	13.6	62.0	NC	27.3	33.3	NC	21.8	50.0	NC	38.2	0.0	5.8
32	31.8	40.8	NC	36.0	17.5	IC	21.0	56.7	NC	29.6	38.3	NC	39.0	0.3	36.2	18.3	IC	36.7	5.0	C	32.5	5.0	C	35.1	9.4	C	35.8	0.6	5.8
33	38.5	25.0	NC	38.8	17.5	IC	20.5	7.0	NC	32.6	37.5	NC	39.0	0.0	34.5	5.8	C	36.2	0.8	C	24.7	40.0	NC	31.8	15.5	C?	36.9	0.8	5.2
34	29.7	20.8	NC	37.2	10.0	C	30.5	31.7	NC	32.5	20.8	NC	39.1	0.6	18.4	52.0	NC	21.0	50.0	NC	19.2	41.7	NC	19.5	47.9	NC	39.1	0.7	7.5
35	36.7	29.2	NC	37.5	8.3	C	34.2	11.7	IC	36.1	16.4	IC	39.4	0.0	23.3	40.0	NC	20.8	46.7	NC	13.8	38.3	NC	19.3	41.7	NC	36.3	0.0	7.3

Oph. gr. + Culture No.	Culture treatments on *Ophiobolus graminis* — Replicate A Ht	A IR	A R	B Ht	B IR	B R	C Ht	C IR	C R	Average Ht	Average IR	Average R	Cult. only Average Ht	Cult. only Average IR
36	36.2	6.7	C	40.8	1.7	C	36.2	1.7	C	37.7	3.4	C	39.8	0.3
o-ck	35.5	33.3		35.2	26.0		30.0	36.0		33.6	31.8			
37	29.8	15.8	IC	37.0	11.7	IC	26.3	15.8	IC	31.0	14.4	IC	37.5	0.6
38	28.5	40.8	NC	40.0	16.7	IC	30.2	8.0	C	32.9	21.9	IC?	40.0	0.6
39	37.5	9.2	C	35.1	13.3	IC	27.8	19.2	IC	33.5	13.9	IC	39.0	0.0
40	39.5	1.7	C	37.1	11.7	IC	26.6	18.3	IC	34.4	10.6	IC	38.2	0.5
41	34.5	10.0	C	34.0	3.3	C	33.0	3.3	C	33.8	5.5	C	38.7	0.0
42	28.3	33.3	NC	34.5	21.7	NC	31.2	8.3	C	31.3	2.4	NC	38.6	0.0
43	39.0	7.5	C	34.8	0.8	C	34.7	6.7	C	36.2	5.0	C	35.7	0.3
44	32.7	5.0	C	35.0	0.0	C	23.7	23.3	NC	30.5	9.4	C	36.3	0.6
45	40.7	0.0	C	36.5	6.7	C	26.3	17.5	IC	34.6	8.1	C	37.8	0.3
o-ck	32.7	41.7		31.7	22.5		31.0	46.7		31.8	37.0			
s-ck	36.3	0.0		38.2	0.0		36.3	0.0		36.9	0.0			
oh-ck	33.5	1.7		31.8	13.3		36.3	0.0		33.9	5.0			
46														
47	36.0	0.0	C	33.7	1.7	C	22.5	24.2	NC	30.9	8.6	C	36.9	1.1
48	36.2	0.8	C	35.5	23.3	NC	28.3	23.3	NC	32.7	15.8	NC?	39.3	0.0
49	38.0	5.0	C	35.3	8.5	C	25.0	0.8	IC	32.8	8.1	C	38.6	0.0
50	39.0	2.5	C	22.8	51.7	NC	29.3	10.0	C	30.4	21.4	C?	38.3	0.8
51	36.8	25.8	NC	33.0	28.3	NC	24.8	58.3	NC	31.5	37.8	NC	36.8	2.0
52	37.5	20.0	IC	36.7	3.3	C	23.5	37.5	NC	32.6	20.3	IC?	38.6	0.0
53	34.0	3.3	C	20.2	50.0	NC	31.0	8.3	C	28.4	20.5	C?	39.1	0.0
54	36.8	2.5	C	26.4	56.0	NC	24.4	18.0	IC	29.2	25.5	IC?	37.3	0.3
o-ck	33.8	51.7		37.0	15.0		30.8	36.7		33.9	34.5			
55	37.3	5.0	C	26.5	50.8	NC	24.8	41.7	NC	29.5	35.8	NC	37.7	0.0
56	38.8	0.0	C	26.3	63.3	NC	24.2	50.0	NC	26.4	37.8	NC	37.3	0.0
57	31.0	0.0	C	26.3	60.0	NC	30.8	14.2	IC	29.4	24.7	C?	38.5	0.0
58	37.8	5.8	C	26.5	5.3	C	28.0	12.5	IC	30.8	7.9	C	37.2	0.3
59	37.7	5.8	C	18.7	75.0	NC	27.8	43.3	NC	28.1	39.7	NC	38.6	0.0
60	36.8	5.8	C	30.5	55.8	NC	18.8	48.3	NC	26.4	36.6	NC	36.2	0.0
61	36.7	5.8	C	30.0	33.3	NC	29.5	24.2	NC	32.1	21.1	NC	38.4	0.0
62	36.5	14.2	IC	31.5	41.7	NC	28.8	14.2	IC	32.3	23.4	IC?	36.9	1.1
63	28.7	33.3	NC	21.7	40.0	NC	24.2	13.3	IC	24.9	28.9	NC	36.0	3.2
o-ck	30.8	30.0		31.0	54.2		25.0	56.7		28.9	47.0			
64	36.2	5.0	C	19.0	68.3	NC	27.2	23.0	NC	27.5	32.1	NC	36.6	0.5
65	33.8	20.8	NC	30.8	45.0	NC	28.7	36.7	NC	31.1	34.2	NC	38.4	1.7
66	34.2	8.3	C	27.3	45.0	NC	26.3	32.5	NC	29.3	28.9	NC	36.2	0.6
67														
o-ck1	30.9	41.5		34.9	31.5		30.7	38.1		32.2	37.0			

Oph. gr. + Culture No.	Filtrate treatments on *Ophiobolus graminis* — Replicate D Ht	D IR	D R	E Ht	E IR	E R	F Ht	F IR	F R	Average Ht	Average IR	Average R	Filt. only Average Ht	Filt. only Average IR	pH
36	20.5	25.0	NC	20.0	35.0	NC	14.8	41.7	NC	18.4	33.9	NC	35.1	0.6	7.0
o-ck	24.0	55.0		18.5	56.7		21.2	41.7		21.2	51.1				
37	19.5	41.7	NC	19.5	28.2	NC	17.8	51.7	NC	18.9	40.5	NC	36.6	0.6	5.9
38	16.5	68.3	NC	17.6	58.0	NC	16.0	53.3	NC	16.7	59.9	NC	37.2	0.6	6.3
39	18.8	51.7	NC	35.7	5.0	C	34.8	5.8	C	29.8	20.8	C?	37.4	0.0	6.5
40	19.3	40.0	NC	20.2	43.3	NC	17.3	38.3	NC	18.9	40.5	NC	35.2	0.6	7.1
41	21.2	43.3	NC	18.0	41.7	NC	20.3	53.3	NC	19.9	46.1	NC	36.2	0.6	7.1
42	17.0	60.0	NC	15.4	58.0	NC	22.2	43.3	NC	18.2	53.8	NC	38.2	0.6	7.1
43	25.0	18.3	IC	24.0	24.0	NC	25.3	36.7	NC	24.8	26.3	NC	38.0	29.4	7.6
44	32.5	11.7	IC	22.5	21.7	NC	28.0	33.3	NC	27.7	23.2	NC	35.4	35.0	6.8
45	18.8	36.7	NC	31.0	8.3	C	36.7	5.8	C	28.8	16.9	C?	36.7	0.0	7.0
o-ck	25.5	56.0		25.0	36.7		25.8	43.3		25.4	45.3				
s-ck	36.3	0.0		38.7	0.0		37.5	0.0		37.5	0.0				
oh-ck	36.3	0.0		37.2	0.8		36.8	0.0		36.8	0.3				
46	20.5	46.7	NC	29.3	41.7	NC	16.0	48.3	NC	21.9	45.6	NC	32.6	1.1	6.5
47	33.0	14.2	IC	33.2	10.0	C	29.5	24.2	NC	31.9	16.1	IC	36.6	0.8	7.8
48	25.3	46.7	NC	36.0	13.3	IC	20.7	43.3	NC	28.3	34.4	NC	38.7	0.0	8.8
49	30.0	17.7	IC	27.7	43.3	NC	28.8	30.0	NC	28.8	30.3	NC	38.6	0.0	3.8
50	23.5	43.3	NC	18.2	48.3	NC	24.5	43.3	NC	22.2	45.0	NC	36.3	0.0	7.0
51	19.5	50.0	NC	21.7	35.0	NC	18.7	51.7	NC	19.6	45.6	NC	39.0	0.0	7.5
52	23.7	43.3	NC	27.7	36.7	NC	21.5	30.0	NC	24.3	36.7	NC	37.9	0.6	7.6
53	20.0	44.2	NC	21.0	43.3	NC	30.5	41.7	NC	23.8	43.1	NC	35.6	0.0	8.4
54	20.2	45.0	NC	22.0	43.3	NC	15.0	45.0	NC	19.1	44.4	NC	35.8	0.0	8.5
o-ck	28.3	30.0		27.5	33.3		32.5	23.3		29.4	28.9				
55															6.2
56	20.7	45.0	NC	19.8	35.0	NC	21.3	50.0	NC	20.6	43.3	NC	36.3	0.0	6.7
57	22.7	40.0	NC	18.6	46.0	NC	19.2	30.0	NC	20.2	58.7	NC	30.1	0.0	9.0
58	19.5	35.8	NC	19.8	46.7	NC	24.2	30.0	NC	21.2	37.5	NC	27.9	0.0	6.7
59	16.3	58.3	NC	27.0	28.3	NC	24.0	48.3	NC	22.4	45.0	NC	35.4	0.0	6.7
60	21.2	45.0	NC	17.3	50.0	NC	14.3	45.0	NC	17.6	46.6	NC	33.1	0.0	6.7
61	15.3	51.7	NC	20.8	42.0	NC	12.4	58.0	NC	16.2	50.6	NC	35.6	0.0	7.6
62	36.0	0.0	C	33.8	2.0	C	32.8	0.0	C	39.2	0.7	C	35.1	0.0	5.5
63	29.8	33.3	NC	27.7	28.3	NC	32.2	28.3	NC	29.9	30.0	NC	34.1	0.8	3.8
o-ck	22.3	35.0		26.2	35.0		24.5	26.7		24.3	32.2				
64	13.2	83.3	NC	17.8	46.7	NC	17.5	53.3	NC	16.2	61.1	NC	34.0	0.3	6.7
65	29.0	38.3	NC	24.2	41.7	NC	28.3	32.0	NC	27.2	37.3	NC	35.0	0.0	7.3
66	19.3	51.7	NC	25.7	45.0	NC	21.8	43.3	NC	22.3	46.7	NC	35.2	0.0	8.8
67	29.8	14.2	IC	24.5	23.3	NC	26.3	23.3	NC	26.9	20.3	NC	32.0	1.1	6.7
o-ck1	25.3	50.4		25.0	39.3		24.9	35.0		25.1	41.6				

Oph. gr. = *Ophiobolus graminis*
Ht = Height in centimeters.
IR = Infection rating in per cent.
R = Reaction C = control.
IC = intermediate control.
NC = no control.

pH = Hydrogen-ion concentration of filtrate.
o-ck = Pots to which only *O. graminis* was added.
s-ck = Pots to which no *O. graminis*, culture, or filtrate was added.
oh-ck = Pots to which sterilized non-inoculated oat hull medium was added.
o-ck1 = Average of all the pots to which only *O. graminis* was added.

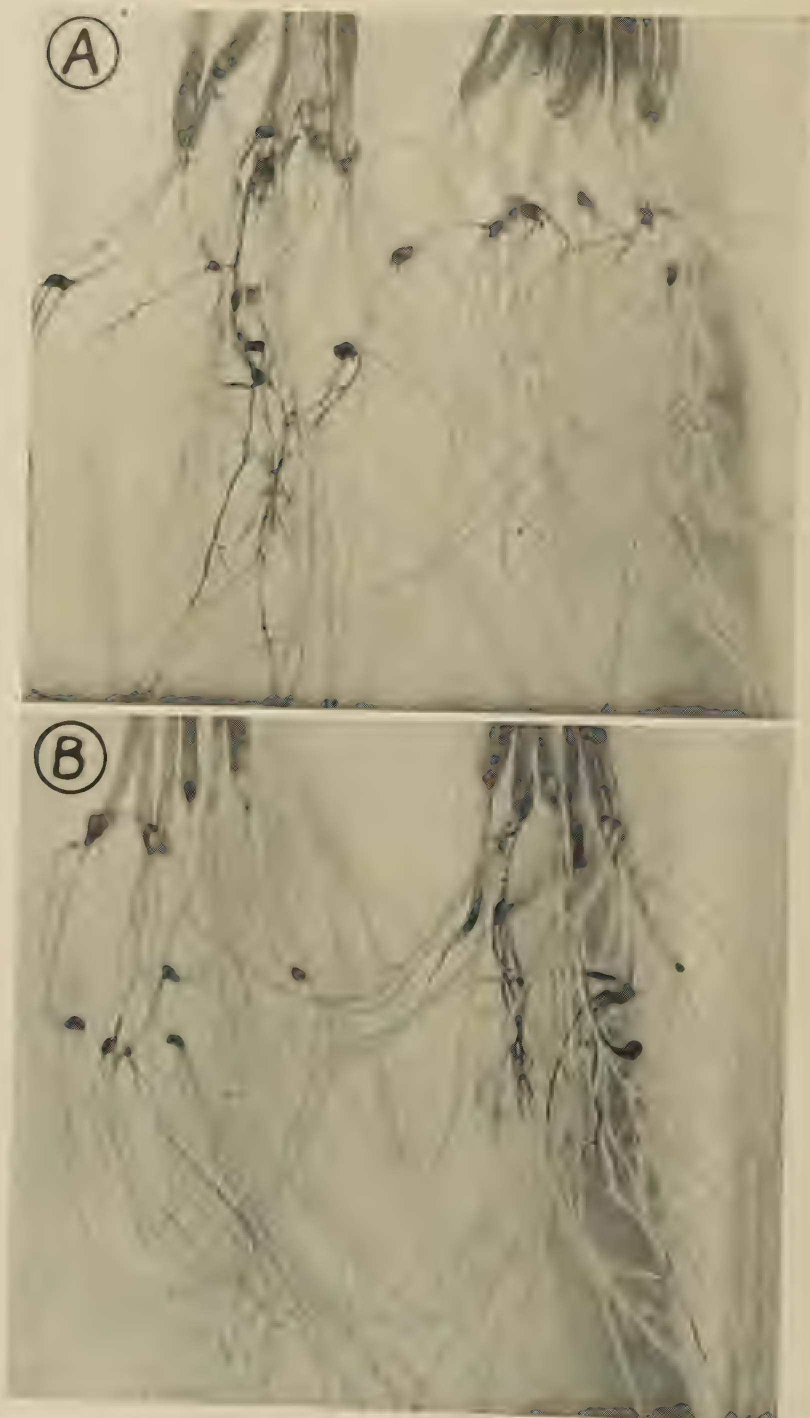

Figure 1.

Figure 1: Differences in control of *Ophiobolus graminis* obtained by certain cultures and their corresponding filtrates. (A) Left, slight protection from culture No. 62 (*Penicillium*); right, good control from its filtrate. (B) Left, good protection from bacterial culture No. 47; right, slight protection from its filtrate.

TABLE 3.—*The effect of the hydrogen-ion concentration of certain filtrates from fungi and bacteria on the reaction of Edmonton loam.*

Culture number	Organism	Initial pH		pH of soil plus filtrate	
		Filtrate	Soil	Jan. 28	Feb. 6
12	*Rhizoctonia solani*	5.5	6.3	6.0	6.3
63	*Rhizopus* sp.	3.8		5.7	6.2
66	Bacteria	8.8		6.7	6.5

The data contained in table 2 is presented graphically in figure 2, charts (A), (B), (C), and (D). In chart (A), the infection curve is abrupt, as it contains only two filtrates, No. 62 (Penicillium, and No. 32 (Actinomyces), in the control class, and one filtrate, No. 16, in the intermediate control class. The curve soon reaches the level of severity of the check pots containing the pathogene alone. A similar situation occurs with the bacterial filtrates, as shown in figure 2, (B). In both cases it is interesting to note that the severity of infection extends beyond the average of that for the pathogene alone, or in other words, some of the filtrates appear to have increased the pathogenicity of *O. graminis.* Those associated with the infection rating beyond 50 per cent are considered as being safely in a class which represents increased injury. Filtrates falling into this class were Nos. 27, 12, and 2 in chart (A), and Nos. 31, 61, 42, 14, 38, and 64, in chart (B).

In figure 2, (C) and (D), the infection rating curve is gradual in its rise, denoting as it does a fairly large proportion of cultures of fungi and bacteria in both the control and the intermediate control classes. This curve reaches the level of severity produced by the pathogene alone (check series) later than it does in the filtrate charts, and it does not rise beyond this level. Thus it would seem that the living cultures do not intensify the severity of the pathogene when associated with it, as some of the filtrate treatments appear to have done. As would be expected, the curve indicating the height of the plants, in the pots receiving both pathogene and treatment, declines in inverse ratio to the infection rating, the drop being greater in the filtrate, charts (A) and (B).

The curve representing the height of the plants in the pots, receiving either a filtrate or culture treatment alone, extends with expected variation in a horizontal direction. In no case is there indicated any deleterious effect on the plants from treatments alone. The data support this again in showing that the average height of plants, where the various treatments were used alone, was roughly the same as that of those grown in soil without any treatment.

Discussion

In discussing the suppressive effect of these organisms on the pathogenicity of *O. graminis*, it is well to recall the great virulence of the pathogene and the rapidity with which wheat seedlings or even older plants were struck down.

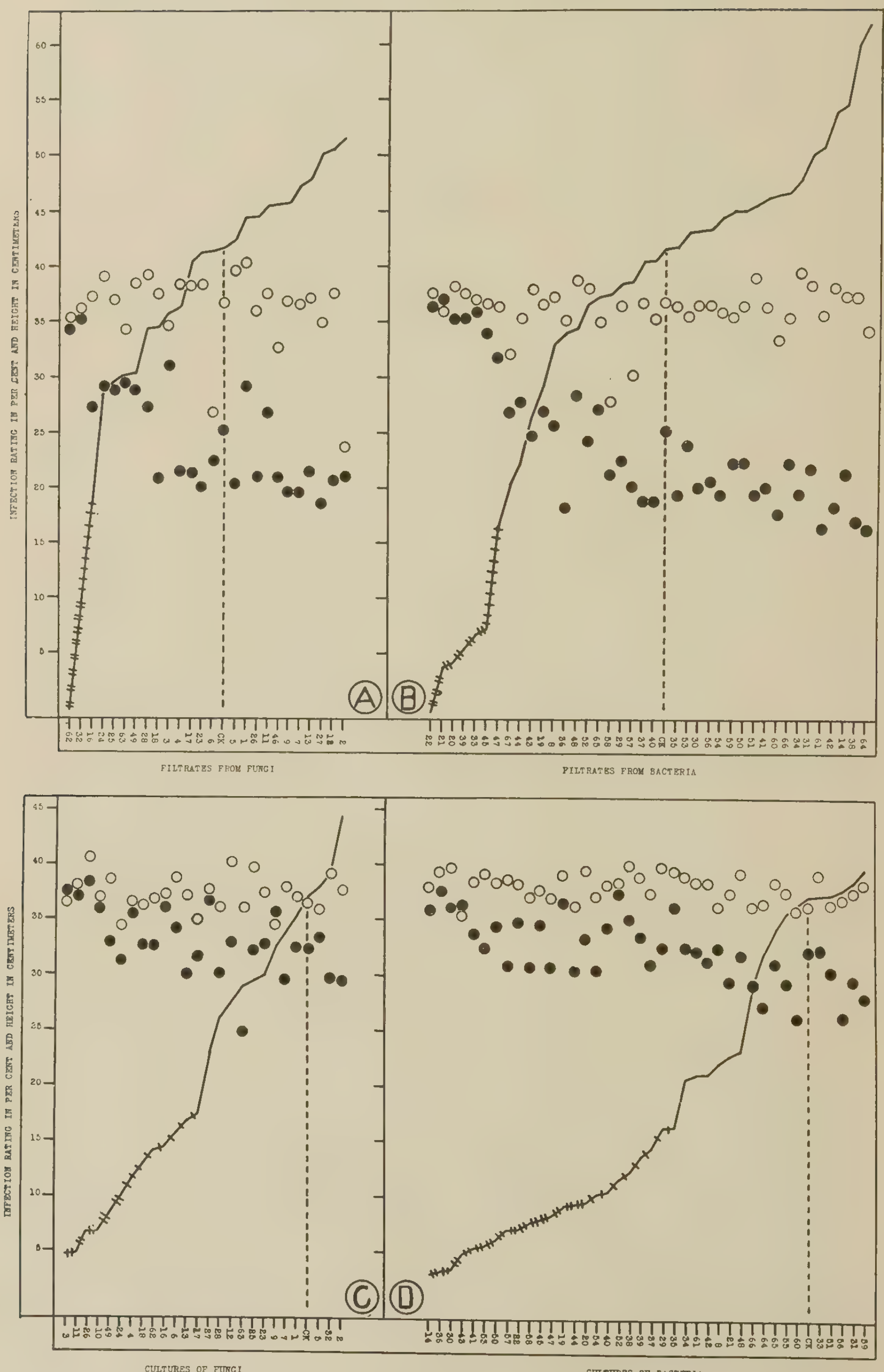

Figure 2.

(See footnote on opposite page for explanation).

The data presented in table 2, and figure 2, demonstrate beyond reasonable doubt that the pathogenicity of *O. graminis* may be profoundly modified, and at times controlled, by the association with it of a number of soil inhabiting bacteria, fungi, and actinomycetes. The same data also show that while its pathogenicity may be modified by some of the micro-organisms, others may actually intensify the injury caused by this pathogene. In producing this condition there does not appear to be any difference whether fungi or bacteria, as *classes*, are concerned, but rather it is a case of the *kind* of organism or organisms which are associated. Therefore, it does not seem reasonable to exclude soil protozoa or other members of the soil fauna—at least until the effects of these have been adequately studied. Of course, the extent to which any of the organisms might be effective under field conditions would depend upon a number of factors of the environment, including the available food in the soil. It is also admitted that, perhaps, the extreme effect from these micro-organisms was obtained in pot culture in sterilized soil. However, here again one cannot reach conclusions without more data, and it would be useless to speculate without this.

Competition for food among micro-organisms, and the effect of their staling products of metabolism on each other, are thought to be important factors when one micro-organism is able to suppress the growth of another. It will be recalled that many more of the living cultures of bacteria or fungi fell into the intermediate control or the control classes, than occurred in the case of the filtrates. However, one is not justified in concluding from this alone that the added protection afforded by the living cultures was due to competition for food, for a number of the filtrates also fell into the control or intermediate control classes, where the competition factor was obviously absent. Again, it would appear that both the pathogene and the added culture should have sufficient available food for good growth in the sterilized soil. *O. graminis* is known to grow well in sterilized soil. In this case it was particularly favoured by being applied to the soil growing on oat hull media. Moreover, most of the bacteria and fungi employed were normal soil organisms and grew well under these conditions, although some less vigorously than others. But an examination of the data shows that a measure of control was often obtained from the cultures which grew less vigorously, while no control was given by some of those cultures known to grow exceptionally well. For instance, bacterial cultures Nos. 56 and 65, and culture No. 63 (Rhizopus) are examples of cultures which grew vigorously but which gave little, if any, control.

That the suppressive effect was probably due to staling products, is strongly suggested by the fact that the filtrates effected control in 8 cases, and intermediate control in 2 instances, where the competition factor would be absent. The suppressive effect must have been due to the toxic quality of the 10 cc.

Figure 2. The effect of 66 cultures of bacteria and fungi and their filtrates on the pathogenicity of *Ophiobolus graminis* on Marquis wheat seedlings. (A) Filtrates from fungi. (B) Filtrates from bacteria. (C) Cultures of fungi. (D) Cultures of bacteria. Solid and barred line indicates the infection rating; double barred part indicates control; single barred part, intermediate control; solid part, no control.

Average height of plants—cultures or filtrates plus *O. graminis*. Average height of plants—cultures or filtrates alone.

of filtrate which was added to the inoculum of *O. graminis*. If toxicity was the chief suppressive factor concerned in these results, it is not surprising to note, in table 2, that more than twice as many living cultures as filtrates fell into the intermediate control class. In attempting to explain this result it might be assumed that the living cultures would continue to elaborate toxic products after they were added to the soil, while the amount of the staling products provided by the filtrates would be definitely limited to the initial amount. Another reason for assuming that toxicity was the suppressive factor concerned, is that, with three exceptions, all the filtrates which gave control or intermediate control were from cultures which also fell in to one of these classes. In further support of this contention, several workers have shown that staling products of micro-organisms do inhibit the activity of others. Sanford (*6*) found that the staling products of a certain bacterial culture (No. 15, about pH 7.3) completely inhibited the growth of *Actinomyces scabies*. Vasudeva (*10*) concluded that the pathogenicity of *Monilia fructiginea* was suppressed by the staling products of *Botrytis Allii*.

It has already been pointed out that the hydrogen-ion reaction of the filtrates did not appear to have any appreciable influence as a suppressive factor . The highly acid reaction of some of the filtrates might have been effective as a suppressive factor were it not for the rather moderate reaction of the soil (pH 6.3) with its strong buffer effect. Further, it will be noted that there were many cases where a filtrate having a reaction of approximately pH 7 suppressed the pathogenicity of *O. graminis* and likewise filtrates with a decidedly acid reaction which did not reduce it. In this connection Schaffnit and Mayer-Hermann (*9*) found that this pathogene grew best in a soil of pH 7.3.

Another interesting feature of the results is that in several of the filtrates from fungi or bacteria, in association with *O. graminis*, the damage from this pathogene was considerably greater than the average for the pathogene alone. In the absence of a definite explanation it is supposed that these filtrates may have contained products which increased the virulence of the pathogene. However, the filtrates which increased the damage from the pathogene did not have any adverse effect on the height of the plants; neither did any of the living cultures. These data are shown in table 2 and figure 2. Obviously the whole phenomenon involves a complex association about which more will be said later.

The results reported in this paper comprise a part of the work undertaken by the authors more than a year ago. The striking effects resulting from the association of various soil organisms with *O. graminis*, shown in this paper, obviously indicate the role that is played by their association in field culture and, therefore, these observations are of particular interest to the root rot problem of cereals, as well as to certain other plant diseases caused by soil-inhabiting pathogenes.

Summary

1. A study has been made of the effects of the association of fungi and bacteria and their filtrates on the pathogenicity of *O. graminis* on wheat

seedlings grown in sterilized soil. This study involved 26 cultures of fungi and 40 cultures of bacteria, nearly all of which were isolated from the soil.

2. Data are given to show that 6 living cultures of fungi and 15 living cultures of bacteria suppressed the pathogenicity of *O. graminis* to a degree varying from almost zero to a 10 per cent infection rating, this being the range arbitrarily set for the control class. Seven cultures of fungi and 8 cultures of bacteria gave intermediate control, which class indicated an infection rating ranging from 10 to 20 per cent. The remaining cultures giving less protection than this were placed in the no control class.

3. Using this same classification, filtrates from 2 cultures of fungi, No. 62 (Penicillium) and No. 32 (Actinomyces), and from 6 cultures of bacteria, fell into the control class. There was one filtrate from a fungus and one from a bacterial culture which fell into the intermediate control class, while the remaining filtrates gave less protection to the plants.

4. Filtrates from 3 cultures of fungi and 6 cultures of bacteria increased the severity of the injury from the pathogene more than 10 per cent beyond that of the damage resulting from the pathogene when used alone.

5. The micro-organisms used, or their filtrates, did not suppress the vigour of the plants under the conditions of the experiment.

6. The data support the view that the toxicity of the living cultures or of their filtrates was the chief factor in suppressing the virulence of the pathogene.

7. In general, the living cultures of fungi and bacteria appear to have been more active than the filtrates in suppressing the pathogenicity of *O. graminis*.

8. The data show that many soil-inhabiting fungi and bacteria are clearly effective in suppressing the pathogenicity of *O. graminis* in soil culture.

The authors wish to express their appreciation for certain apparatus supplied by the University Department of Field Crops and by the Department of Chemistry, and also to Dr. H. T. Güssow, Dominion Botanist, for reading the manuscript.

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BOOK REVIEW

"Farm Crop Projects"—Burlison & Nolan. (Published by The Macmillan Co. of Canada, Toronto, Ont. Price $2.25).

It is generally recognized that the future of agriculture lies in education. This being so, it is most important that our teachers of agriculture be not only up-to-date on their data but also efficient in their teaching methods. In the book "Farm Crop Projects" by Burlison and Nolan, teachers of agriculture in high and vocational schools will find a text of real merit. Realizing the truth of the principle "learn to do by doing", the authors have outlined their work on the basis of projects. It is only by linking up the principles with the practical application in the field that the greatest progress and interest will be achieved.

The authors, Dr. Burlison and Professor Nolan have had wide experience. From their joint observation in the field of pedagogy, as experimentalists, as extension specialists and in practical farming they are well qualified to handle the subjects under discussion.

Teachers of agriculture who are endeavouring to co-ordinate lecture and laboratory work with definite projects conducted in the field will find this book of real assistance. The material is practical, up-to-date and covers a wide variety of crops suitable to Canadian agriculture.

J. E. W.

BACTERIAL FRUIT BLIGHT OF THE LOGANBERRY

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[Received for publication January 12, 1931]

Introduction

In June, 1930, the author's attention was directed to a destructive disease of the loganberry which has caused considerable loss to the British Columbia growers for a number of years. In many of the fields from fifty to eighty percent of the fruits were blighted. The estimated loss from this disease was approximately $200,000.

Many observers considered that the disease was physiological. Examinations made in the field indicated otherwise and therefore it was decided to make further investigations. In this preliminary paper the results of numerous isolations, inoculations and re-isolations are given which indicate that the disease is caused by bacteria.

Symptoms of the Disease

The principal symptom of the disease is a necrosis of the fruits. The receptacles and the druplets of the infected immature fruits are usually completely blighted, turning brown in colour. Occasionally, however, only partial blighting occurs. The discoloration usually extends down the peduncle for a short distance, approximately half an inch. Sometimes it may extend farther down the flower pedicel but rarely as far as the cane. As the season advances the mature fruit may become affected. The diseased ripe berries dry up prematurely. The general symptoms are well illustrated in Plate I, in which both the healthy and diseased fruits are shown.

Cause of the Disease

Isolation of the Causal Organism

In the search for the causal organism, the method most commonly used was to wash young discoloured receptacles of the loganberry in 70 per cent ethyl alcohol, dip in mercuric chloride 1:1000 for half a minute and then wash again in the alcohol. The receptacles were then transferred to plates of potato-dextrose agar and incubated at room temperature, approximately 20°C. Within two to three days bacterial colonies appeared, and pure cultures were obtained from the predominant type by the high dilution method. Inoculations were then made to determine if this organism was pathogenic.

Pathogenicity Studies

Loganberries, raspberries and thimbleberries were inoculated. The bacteria were introduced into the buds, flowers and fruits at the base of the receptacle by wounding and inoculating with a dissecting needle. The check fruits were also wounded, with a flamed dissecting needle. In the field, the portions of the plant under observation were protected by placing them in Erlenmeyer flasks partly filled with water and closed at the mouth with non-absorbent cotton. The results of the inoculations are shown in table 1.

*Assistant Provincial Plant Pathologist.

Plate I. Diseased and healthy fruits of the loganberry.

TABLE 1.—*Results of inoculating the immature fruits of the loganberry and raspberry in the field with an organism isolated from the loganberry.*

Date	Treatment	Species of Rubus	Result
July 2	Check	Loganberry	—
	Inoculated	Loganberry	+
July 4	Check	Loganberry	—
	Inoculated	Loganberry	+
July 7	Check	Loganberry	—
	Inoculated	Loganberry	+ +
	Check	*idaeus*	—
	Inoculated	*idaeus*	+ +

— No effect. + partial necrosis. + + general necrosis.

Both loganberry and raspberry developed typical symptoms of the disease after they had been artificially inoculated. The same organism was re-isolated from the receptacles of the diseased berries.

In the laboratory, the buds, flowers, and fruits were placed into large test tubes partly filled with water and closed at the mouth with non-absorbent cotton. They were then inoculated. The results are shown in tables 2 and 3.

TABLE 2.—*Results of inoculating loganberry, raspberry and thimbleberry in the laboratory, with the organism isolated from loganberry.*

Date	Treatment	Species of Rubus	Result
July 10	Check	Loganberry	—
	Inoculated	Loganberry	+ +
	Check	*idaeus*	—
	Inoculated	*idaeus*	+ +
	Check	*parviflorus*	—
	Inoculated	*parviflorus*	+ +

— No effect. + partial necrosis. + + general necrosis.

In a week's time the inoculated buds, flowers, and fruits of all three hosts, (loganberry, raspberry and thimbleberry) developed typical disease symptoms, and the causal organism was re-isolated from the infected tissue. Table 3 summarizes the results of inoculating loganberries at different stages of development.

TABLE 3.—*Results of inoculating flowers and fruits of loganberry at different stages of development with the organism isolated from loganberry.*

Treatment	Stages of flower or fruit	Result
Check	All stages	—
Inoculated	Bud	+ +
Inoculated	Flower	+ +
Inoculated	Small immature fruit	+
Inoculated	Large immature fruit	—
Inoculated	Mature fruit	+ ?

— No. effect. + partial necrosis. + + general necrosis.

The laboratory studies indicate that infection of loganberries takes place more readily during the bud and flower stage, than later. The effect of inoculating in the budding stage is shown in figure 2. In general, artificial inoculation of the small immature fruits brought about partial necrosis, though complete necrosis sometimes developed. Negative results, however, were obtained when the large immature fruits were inoculated.

Description of the Pathogene

Morphology

The organism is a large, gram positive, bi-polar stained rod shaped bacillus with rounded ends, (figure 3) and measures 0.8 to 1.0 by 1.5 to 5.0 microns. The average dimensions are approximately 0.8 by 3.0 microns. The pathogene occurs singly and in chains. The organism is motile in hanging drop preparations of broth and agar cultures. It has several peritrichic flagella, which were successfully stained by Leifson's (*4*) method. On potato-dextrose agar slants a week old, excentric spores were observed and the bacillus was slightly swollen at the position of the spore. When the organism was introduced into sterile water and heated to 85°C. for ten minutes, or to 70°C. for thirty minutes, it was not killed. Consequently according to the Society of American Bacteriologists (*2*) the endospores may be regarded as unquestionably present. The presence of endospores was carefully checked because—it is said—spore-formers are exceedingly rare as plant pathogenes.

Figure 1. Diseased and healthy fruits of the Thimbleberry, *Rubus parviflorus*, Nutt.

Figure 2. A *Rubus* sp. inoculated in the budding stage.

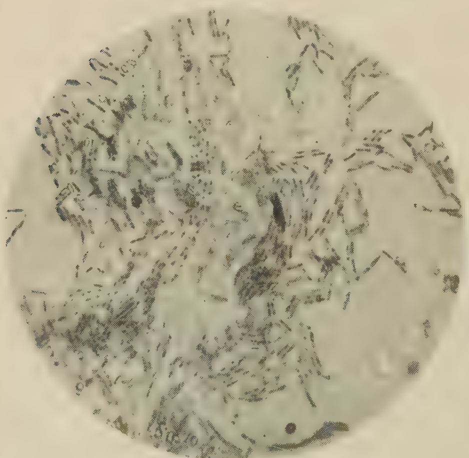

Figure 3. The causal organism showing long bi-polar stained rods and a few spores.

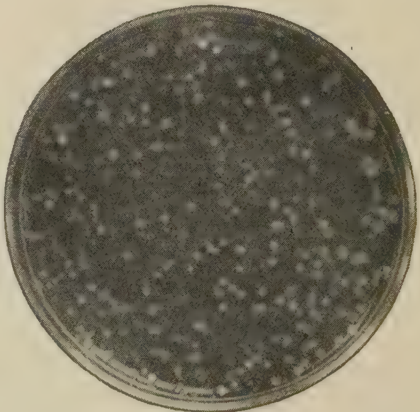

Figure 4. Colonies of the loganberry organism on potato-dextrose agar.

Cultural Characteristics

On the following media the loganberry organism was incubated at room temperature, approximately 20°C.

Agar colonies. The colonies as shown in figure 4, are circular, unbonate, raised, curled, yellowish grey, centre opaque, edge translucent and butryrous.

Agar slant. The growth is smooth, moderate filiform, raised, butyrous, opaque and yellowish-grey.

Gelatine colonies. The growth is slow, circular and yellowish-grey.

Gelatin stab. Liquefaction is very slow and stratiform.

Broth. Three days after inoculation, slightly turbid. After the third day, clear with greyish granular sediment.

Litmus Milk. This is coagulated and reaction is alkaline.

Potato. There is slight growth at first but gradually becomes heavier. The colony is yellow in colour and butyrous.

Indol not formed.

Nitrates not reduced.

No gas or acid was formed in lactose, glucose, saccharose, mannite, maltose, galactose, raffinose, dulcite, dextrin, and inulin.

Starch is hydrolyzed.

Aerobic.

Optimum growth temperature approximately 25°C. There was no growth at 10° and 40°C.

Group number: Using the 1928 chart issued by the Society of American Bacteriologists (*2*) the index number is 5210, 32100, 1000.

Name: According to Migula's classification and the classification of the Society of American Bacteriologists, the organism is a bacillus, and the specific name *Bacillus desiccans* n. sp. is suggested.

Host Relations

Fruit blight was found on all of the Rubus species examined. The loganberry, the raspberry, *Rubus idaeus* Linn., the cultivated and wild blackberry, *Rubus fructicosus* Linn., *and Rubus macropetalus* Dougl., respectively, and the thimbleberry, *Rubus parviflorus* Nutt., are all susceptible. The effect of the organism on fruits of the latter species are shown in figure 1. The following were successfully infected by artificial inoculation, the loganberry, raspberry, and thimbleberry.

Predisposing Factors

From observations and data obtained from the growers, it appears that any condition which favors a succulent growth renders the host more susceptible. The young growing tissues, druplets and receptacles, in the early part of the season are evidently more susceptible than the older tissues. In the early fruits, the percentage of infection was much higher than in the late ones. The bacterial fruit blight also appeared to be increased in severity by the cloudy and humid weather of the early part of the season. The application of liquid manure and other nitrogenous fertilizers also appeared to increase the incidence of infection.

Summary

1. For a number of years, a blight of the immature fruits of the loganberry caused considerable loss in British Columbia.

2. In 1930, the disease was serious. In many of the fields fifty to eighty per cent of the fruits were blighted.

3. The symptoms are a necrosis and a desiccated condition of the fruit.

4. An organism was isolated from the diseased loganberry fruits in July, 1930, and its pathogenicity was proved by inoculation and re-isolation both in the field and in the laboratory.

5. The same organism was also isolated from the wild blackberry, *Rubus macropetalus* Dougl., and the thimbleberry, *Rubus parviflorus* Nutt.

6. When the immature fruits of the raspberry, *Rubus idaeus* Linn., and the thimbleberry, *Rubus parviflorus* Nutt., were artificially inoculated typical symptoms of the disease developed.

7. Using the S.A.B. (1928) Chart, the index number for the pathogene is 5210, 32100, 1000.

8. Following Migula's classification the organism is a bacillus, and the specific name *Bacillus desiccans,* n. sp. is suggested.

Acknowledgement

In connection with this investigation thanks are expressed to Mr. J. W. Eastham and Dr. Wm. Newton for criticism and helpful suggestions in the preparation of this preliminary paper, and to the Provincial Bacteriological Laboratory, University of Alberta, for assistance in checking the observations on the morphological and cultural characteristics of the loganberry organism.

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SULPHUR OXIDATION AND REACTION EFFECTS IN ALBERTA SOILS*

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Sulphur is a constitutent of proteins and is therefore essential to life in all its diversity. The sulphur necessary for plant growth must be found in the soil in soluble form. The sulphur which exists in air, usually combined with oxygen, is present in very small amounts as compared with nitrogen and oxygen and is not directly available as plant food. Waksman (*5*) states that, "Sulphur resembles nitrogen in the transformations into which it enters and in the types of microörganisms which causes these transformations. There is in the sulphur cycle apparent duplication of the processes associated with the nitrogen cycle". The transformations to which sulphur is subjected in the soil may be summarized under four headings: (1) oxidation, (2) reduction, (3) synthesis into proteins, and (4) decomposition of proteins and protein derivatives containing sulphur. Microörganisms are generally conceded to be essential for most of these changes of sulphur, excepting the synthesizing processes. Purely chemical changes, however, are not excluded as contributary factors in the various transformations.

Sulphur may occur distributed throughout the soil to a considerable depth. Owing to the relatively high solubility of certain sulphate salts, it is not uncommon to find that these have leached to certain depths forming sulphate concentration layers at the point of precipitation of the salts. Most of the soils of Alberta (*6, 7*) possess sufficient sulphur for normal crop needs, although certain soils have undergone considerable leaching.

The sulphur oxidizing power of soils is by no means a new subject of investigation. It has been studied by many workers (*2, 3, 4*).

In the study of the oxidizing power of Alberta soils, samples representing the three major soil belts of the province were used (*8, 9*). The Beaverlodge loam, representing the Black Soil belt, resembles the better known Edmonton loam. The sample used was a virgin black loam, high in organic matter, containing 0.626 per cent of nitrogen and approximately 0.065 per cent of sulphur. The Pigeon Lake loam, representing the Wooded Soil belt, was somewhat higher in nitrogen content than the average soil of this type, as it contained 0.230 per cent nitrogen; the sulphur content of similar soils is approximately 0.030 per cent. The Brooks loam, representing the Brown Soil belt, had a nitrogen content of 0.131 per cent and soils from the same locality contain 0.045 per cent of sulphur.

The soils were ground to pass a 20 mesh screen and thoroughly air dried at room temperature. 100 gram samples of the dry soil were placed in glass tumblers and the computed fertilizer supplement thoroughly mixed with the soil. ‡

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*Thesis submitted to the University of Alberta in 1929 in partial fulfilment of the requirements for the degree of Master of Science.

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Acknowledgment is due Dr. J. D. Newton, for suggesting the problem and for supervising the investigation. Acknowledgment is also due Dr. F. A. Wyatt, for assistance in interpreting the data.

‡The sulphur and other fertilizer supplements were added at the rates of stated numbers of pounds per acre. The weight of an acre of soil is here taken as 2,000,000 pounds, which is approximately the weight of seven acre inches of soil.

Table 1.—*Oxidation of sulphur in black belt soil (Beaverlodge loam). Results expressed as pounds of sulphur per acre (2,000,000 lbs. soil).*

Treatment in pounds per acre	2 Weeks		4 Weeks		6 Weeks		8 Weeks		10 Weeks	
	S. in Sulphates	Increase over S. alone	S. in Sulphates	Increase over S. alone	S. in Sulphates	Increase over S. alone	S. in Sulphates	Increase over S. alone	S. in Sulphates	Increase over S. alone
Sulphur 2,000	423		1536		1678		1473		1453	
No treatment	212		331		239		323		319	
Difference due to S	211		1205		1439		1150		1134	
Clover 20,000 } Sulphur 2,000 }	417		559		1270		1227		1466	
Clover 20,000	146		162		259		225		277	
Difference due to S	271	60	397	–808	1011	–428	1002	–148	1189	55
Superphosphate 4,000 } Sulphur 2,000 }	1189		1350		1852		1731		2063	
Superphosphate 4000	592		482		601		677		612	
Difference due to S	597	386	868	–337	1251	–188	1054	– 96	1451	317
$CaCO_3$ 10,000 } Sulphur 2,000 }	891		669		1727		1228		1650	
$CaCO_3$ 10,000	385		484		594		351		295	
Difference due to S	506	295	185	–1020	1133	–306	877	–273	1355	221

Table 2.—*Oxidation of sulphur in wooded belt soil (Pigeon Lake loam). Results expressed as pounds of sulphur per acre (2,000,000 lbs. soil).*

Treatment in pounds per acre	2 Weeks		4 Weeks		6 Weeks		8 Weeks		10 Weeks	
	S. in Sulphates	Increase over S. alone	S. in Sulphates	Increase over S. alone	S. in Sulphates	Increase over S. alone	S. in Sulphates	Increase over S. alone	S. in Sulphates	Increase over S. alone
Sulphur 2,000	551		793		564		1049		755	
No treatment	101		119		147		151		94	
Difference due to S	450		674		417		898		661	
Clover 20,000 } Sulphur 2,000 }	345		513		821		824		948	
Clover 20,000	140		118		128		152		179	
Difference due to S	205	–245	395	–279	693	276	672	–226	769	108
Superphosphate 4,000 } Sulphur 2,000 }	531		923		770		732		1044	
Superphosphate 4,000	417		421		441		443		434	
Difference due to S	114	–336	502	–172	329	–88	289	–609	610	–51
$CaCO_3$ 10,000 } Sulphur 2,000 }	725		701		541		709		931	
$CaCO_3$ 10,000	115		182		158		158		126	
Difference due to S	610	160	519	–155	383	–34	551	–347	805	144

These fertilizer supplements consisted of the following materials: finely ground dried sweet clover, calcium carbonate (C.P.), superphosphate, flowers of sulphur.

Sufficient water was added to bring the soil to optimum moisture content. Incubation was carried on at room temperature for intervals of from 2 to 14 weeks. The soil was cultivated and brought up to optimum moisture content twice each week. At the end of the incubation period a portion of the sample was oven dried and soluble sulphates determined. The soil reaction was determined colorimetrically on the moist samples, using a set of buffer solutions (*1*) which had been checked with a potentiometer.

The results obtained with sulphur oxidation in the soils from the three soil belts are reported and expressed as averages from duplicates in tables 1 to 3.

From the data in tables 1 to 3 it is apparent that all samples receiving no sulphur changed in soluble sulphate content to some extent as the incubation period progressed, although on the whole they remained fairly constant. Comparisons of the untreated lots from the three soils showed that the Beaverlodge loam was from one and one-half to two times as high in native sulphates (210 to 330 lbs. sulphur) as the other two soils. The Brooks loam was slightly higher in native sulphates than the Pigeon Lake loam (140 to 160 and 90 to 150 lbs. sulphur, respectively).

In comparing the effect of the different fertilizer supplements it is apparent that where superphosphate was added the sulphate content is nearly three times greater than that of the untreated samples. However, if the amount of sulphate sulphur in the untreated samples is first subtracted from the superphosphate supplemented samples, it is at once seen that the sulphate content is approximately the same throughout for the three soils. The increase in the sulphates of the superphosphate treated samples over the untreated lots is ascribed to the sulphates present in the superphosphate fertilizer itself. The calcium carbonate is the only supplement which has had any apparent effect on the native sulphate content, and then only in the case of the Beaverlodge loam, where it doubled the sulphate content during the first six weeks of incubation.

In considering the rate or velocity of the reaction as distinct from the total amount of sulphate sulphur produced there are apparent differences between the three soils. In the Beaverlodge loam, table 1, for the treatments with sulphur alone, the increments at the end of each incubation period over the period immediately preceding, after subtracting the sulphates of the untreated samples, were as follows: 211, 994, 234, -289 and -16 pounds of sulphate sulphur at the end of 2, 4, 6, 8 and 10 weeks respectively. From a consideration of these figures it is apparent that the velocity of the reaction had reached a maximum at the end of the 4-week period. The peak of total sulphate accumulation, however, was not reached until after six weeks, when 70 per cent or 1439 pounds of the added sulphur had accumulated as sulphate. A drop in total sulphates is noticeable at the 8- and 10-week periods. It is doubtful, however, if this difference is significant. Evidently oxidation of the remaining sulphur was only proceeding slowly, if at all, or the sulphate was perhaps reacting with certain soil con-

TABLE 3.—*Oxidation of sulphur in brown belt soil (Brooks loam). Results expressed as pounds of sulphur per acre. (2,000,000 lbs. soil).*

Treatment in pounds per acre.	6 Weeks		10 Weeks		14 Weeks	
	S. in Sulphates	Increase over S. alone	S. in Sulphates	Increase over S. alone	Increase Sulphates	Increase over S. alone
Sulphur 6,000	1921		2333		3303	
Sulphur 2,000	1154		1089		1390	
No treatment	141		163		156	
Difference due to S.	1013		926		1234	
Clover 20,000 + Sulphur 2,000	958		1270		1305	
Clover 20,000	88		145		167	
Difference due to S.	870	−143	1125	199	1138	−96
Superphosphate 4,000 + Sulphur 2,000	1452		1516		1462	
Superphosphate 4,000	511		587		448	
Difference due to S.	941	−72	929	3	1014	−220
$CaCO_3$ 10,000 + Sulphur 2,000	1218		1467		1112	
$CaCO_3$ 10,000	116		198		119	
Difference due to S.	1102	89	1269	343	993	−241

stituents to form insoluble compounds which, in turn, would not be included in the soluble sulphate figures.

The sulphur oxidizing power of the Pigeon Lake loam (table 2) is on the whole much lower and more irregular than that of the Beaverlodge loam, as shown by the rate of oxidation and maximum accumulation of sulphate sulphur. The increments at the end of each period over the preceding period, calculated as for the Beaverlodge loam, were as follows: 450, 224, -257, 481, -237 pounds of sulphate sulphur. The peak of total sulphate accumulation occurred at the end of the 8-week period when 45 per cent or 898 pounds of the added sulphur had been oxidized. As in the case of the Beaverlodge loam, there may have been a conversion of sulphates from the soluble to the insoluble state.

The experiments with the Brooks loam (table 3) were conducted after some of the results were available for the Beaverlodge and Pigeon Lake soils. Since the reaction had not been appreciably modified by the 2,000 lbs. application of sulphur, a series using 6,000 lbs. of sulphur was included in the Brooks experiments. In the previous two series of experiments complete oxidation of the added sulphur apparently had not taken place at the end of 10 weeks, therefore the incubation period was lengthened to 14 weeks.

Where sulphur was applied alone the samples receiving the 2,000 lbs. application had 50 per cent of the sulphur oxidized at the end of 6 weeks and only slightly over 60 per cent at the end of 14 weeks. With the 6,000 lbs. sulphur application, approximately 30, 37 and 53 per cent of the added

sulphur had been oxidized at the end of 6, 10 and 14 weeks respectively. These figures indicate that the sulphur oxidizing microörganisms are incapable of oxidizing as great a percentage of the sulphur where large applications are made, although the total amount of sulphur oxidized is about two and one-half times as great with the 3-ton as with the 1-ton application (upper part table 3).

If the results for the supplemented sulphur treatments, after subtracting the sulphates due to the supplementary fertilizers, are analyzed in the same way, it is apparent that they all had the maximum rate of oxidation during the first six weeks of incubation in the Beaverlodge loam (table 1). From the sixth to the tenth week of incubation there was a slowing down of the rate of oxidation or the sulphates had been converted to the insoluble state. The maximum accumulation occurred with all three supplements at the end of ten weeks.

In order to determine the effect of the supplementary fertilizers on sulphur oxidation it is necessary to compare the results of the supplemented sulphur treatments with sulphur alone. These results are tabulated in the second column of each incubation period. After a somewhat beneficial effect during the first two weeks of incubation, all supplements have retarded oxidation until after the 8-week period. After the 10-week period there is a slight beneficial effect in all cases. The organic matter and calcium carbonate caused considerable retardation in the oxidation process during part of the incubation period.

In the Pigeon Lake loam (table 2) the supplementary treatments have had less effect on the rate of sulphur oxidation than in the Beaverlodge soil. With two exceptions ($CaCO_3$ after the 2-week and clover after the 6-week incubation periods), all supplements have depressed sulphur oxidation until after the 8-week period. Clover and calcium carbonate produced a beneficial effect during the 10-week incubation period. Superphosphate, however, had a depressing effect on sulphur oxidation throughout. It is noteworthy, however, that the sulphur and the sulphur supplemented treatments, excepting clover, all fluctuated considerably. The organic matter, on the other hand, had a stabilizing influence as there was a steady and gradual increase in soluble sulphates as the incubation period progressed. This observation is in accord with the results obtanied with the Beaverlodge loam, although in the latter the effect is less marked, which is to be expected with a soil already rich in organic matter.

In the Brooks loam (table 3) the sulphur supplements, after some fluctuation throughout the incubation period, appear finally to have had a slightly detrimental effect. The sulphur alone, however, behaved as erratically as any treatment and it is therefore difficult to draw a definite conclusion as to the effect of the supplements.

It is apparent that each of the three soils studied possesses a definite sulphur oxidizing power capable of converting added sulphur into soluble sulphates. The oxidizing power of the three soils is in the same order as their native sulphates, the Beaverlodge and Brooks soils being nearly equal in their oxidizing power, and both considerably higher than that of the Pigeon Lake soil.

TABLE 4.—*The effect of various treatments on the soil reaction expressed as pH values.*

Treatment per acre (2,000,000 lbs.)	pH values at 6, 10 and 14 weeks.								
	Beaverlodge Loam			Pigeon Lake Loam			Brooks Loam		
	6	10	14	6	10	14	6	10	14
No treatment	6.2	6.5	7.0	6.0	5.8	6.65	7.0	7.15	7.15
Clover—10 tons	6.4	6.3	6.6	6.05	6.2	6.65	6.8	7.0	7.1
Clover—20 tons	6.6	6.45	6.7	6.0	6.1	6.7	7.15	6.85	7.2
Sulphur—1 ton	6.3	6.45	6.6	5.6	6.4	6.45	5.8	6.4	6.6
Sulphur—3 tons	6.3	6.4	6.5	3.5 4.4*	3.4	3.2	5.3	4.25	4.2
Soil at beginning of experiment	6.4			6.2			7.2		

* All other values are averages of closely agreeing duplicate samples.

The effect of fertilizers on the soil reaction of the three soils is reported in table 4.

A preliminary part of the investigation showed that certain fertilizers had no apparent effect on the reaction of the soils under investigation and these were therefore eliminated.

At the beginning of the experiment the air-dry Beaverlodge and Pigeon Lake soils were slightly acid and the Brooks soil slightly alkaline in reaction. These reactions, however, are all well within the limits of normal productive soils.

The Beaverlodge loam remained practically unaffected by all treatments, although it showed a tendency to approach the point of neutrality as the incubation period progressed. This soil apparently possesses a large buffer capacity as indicated by the unchanged reaction where 6,000 lbs. of sulphur had been added, of which in all probability at least one-half had been oxidized at the end of 14 weeks.

The reactions of the Pigeon Lake and Brooks soils are very similar; both tended towards neutrality except where sulphur had been applied. A small depression in pH was noticeable after 6 weeks, with the 1-ton sulphur application, but this increase in hydrogen-ion concentration was not maintained at the end of 10 weeks. The 3-ton sulphur application, however, produced a pronounced change in the soil reaction. The Pigeon Lake soil changed from pH 6.2 to 3.5 and 4.4 (for duplicate samples), and the Brooks loam from pH 7.2 to 5.3 at the end of six weeks. At the end of 10 weeks the latter soil had changed to pH 4.2 while the former was practically unchanged at pH 3.4. These concentrations were practically maintained at the end of 14 weeks. Although the Pigeon Lake loam possesses a considerably lower oxidizing power than the Brooks loam, the change in soil reaction is nearly the same. This result therefore indicates that the Pigeon Lake loam possesses a somewhat lower buffer capacity than the Brooks soil. It should be kept in mind, however, that the buffer capacity of soils is dependent on several variable factors.

Summary

The sulphur oxidizing power of three soils, each from a different major soil belt of Alberta, was determined by a laboratory experiment, using the soluble sulphates as an index.

The Black, Brown and Wooded belt soils under investigation all possess definite and vigorous sulphur oxidizing powers. The greatest rate of oxidation took place during the first six weeks of incubation. A marked difference exists in the oxidizing power of the three soils studied. The Black soil possesses the highest capacity, the Brown soil is somewhat lower and the Wooded soil is considerably lower, with only about one-half the oxidizing capacity of the Black soil.

The supplementary fertilizers did not consistently increase or decrease the rate of sulphur oxidation in the soils, except in one case, in which superphosphate added to Wooded soil caused a depression of the sulphur oxidized at the end of each incubation period as compared with sulphur alone. The organic matter (clover) had a stabilizing effect on sulphur oxidation in all soils, tending to produce a steadier increase in the amounts of sulphur oxidized.

No direct correlation exists between the amounts of sulphur oxidized and the change in hydrogen-ion concentration with treatments up to 6,000 lbs. of sulphur per acre when soils of different buffer capacity are compared. The 2,000 lbs. applications of sulphur had produced some change at the end of 6 weeks in the Brooks and Pigeon Lake loams. These soils, however, had reverted approximately to their original reaction after 10 weeks. With the 6,000 lbs. sulphur application these two soils showed approximately the same numerical change in pH values, the Pigeon Lake loam changing from pH 6.2 to 3.2 and the Brooks loam from pH 7.2 to 4.2.

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TITRATION CURVES OF FRUIT AND VEGETABLE JUICES AND CULTURE MEDIA *

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The fermentation studies of this laboratory have suggested that more information can be obtained with the same expenditure of labour from titration curves than from data obtained by any other analytical method. A number of titration curves follow which illustrate their possible significance in fermentation and plant disease studies. They were obtained by titrating fruit and vegetable juices and culture media with tenth normal sodium hydroxide, and by determining the hydrogen ion concentration potentiometrically using a hydrogen electrode against a saturated potassium chloride calomel half cell.

A quantitative view of the acidic constituents of loganberry juice in relation to the maturation of the fruit is revealed in figure 1. A titration curve of citric acid is included to indicate whether titration curves suggest the presence of specific acids. Nelson (*1*) has reported that the acids of loganberries consist of 96 per cent citric and 4 per cent l-malic. The comparison of the citric acid and loganberry curves shows that compounds other than citric acid play a part in the acid base equilibrium of loganberry juice. The curves reveal that the initial pH values do not progressively increase with maturity. The curves also indicate that loganberry juice has to be titrated to approximately pH 6.5 in the determination of the total acid, particularly if immature red and green fruit are analyzed. It is apparent from figure 1, that the total acid, but not the initial pH values of the juice, reveal the state of maturity. This is of interest to the manufacurer of loganberry wine, for our investigations indicate that the more mature is the fruit, the better is the quality of the wine therefrom.

Figure 2 reveals the character of loganberry juice that was expressed from berries received by a local wine company near the beginning, midseason, and towards the end of the season of 1930. The initial pH values of the different samples are practically identical, and although there is a slight decrease in the total acid by midseason, the striking decrease does not occur until near the end of the season. The shapes of the curves suggest that there occurs a quantitative but not a qualitative change in the acidic and basic constituents during the season.

The alteration in the acid base equilibrium through fermentation is revealed in figure 3. The titration curves represent unfermented loganberry must, and must after it has been fermented for one month at 25°C. with two distinct yeast species respectively. One form, No. 157, develops pink colonies on agar plates, produces a heavy film on loganberry and other liquid media, but does not produce significant quantities of ethyl alcohol. The other form, No. 308, is one of the predominating wine yeasts found in loganberry must towards the end of the natural fermentation process. The loganberry must fermented by this yeast contained over fifteen percent

*Contribution from the Division of Botany, Experimental Farms Branch.
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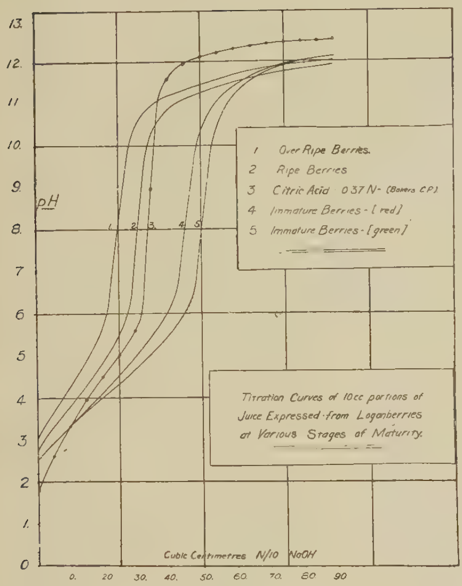

FIGURE 1.
Loganberry juice and citric acid.

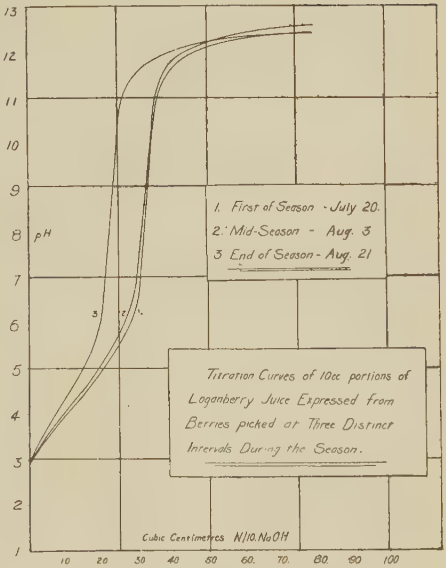

FIGURE 2.
Loganberry juice.

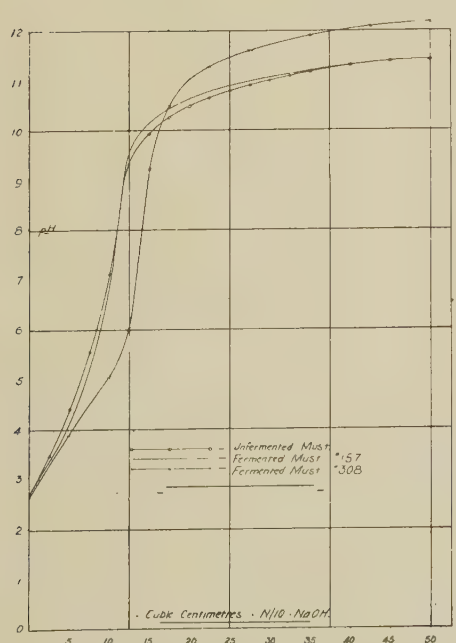

FIGURE 3.
Fermented and unfermented loganberry must.

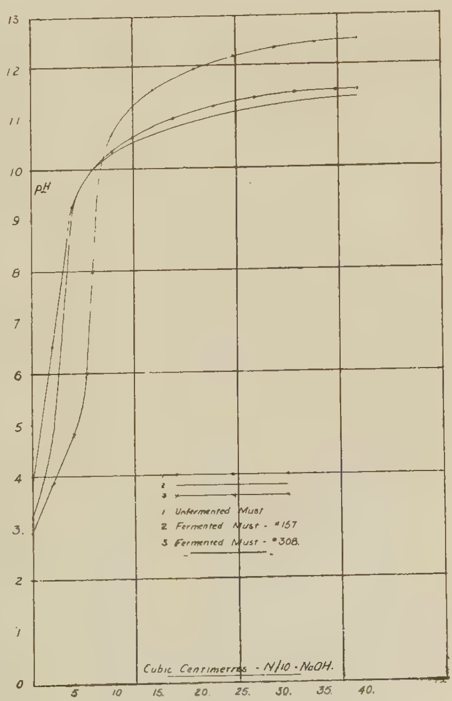

FIGURE 4.
Fermented and unfermented cherry must.

alcohol. The graphs indicate that No. 157 increases the total acid but not to the same extent as the wine yeast. It is also evident that the wine yeast brings about qualitative as well as quantitative changes in the medium, for the critical change in the slope of the curve occurs at a much higher pH value than in the cases of the unfermented must and the must fermented by No. 157.

The effect of the same yeasts upon a different substrate is shown in figure 4. Cherry in place of loganberry must has been fermented. The shapes of the curves are practically identical to those of figure 3, indicating that the type of fermentation is similar in both substrata. Both musts were prepared by using the same proportions of juice and sucrose syrup. The disappearance of the sugar and the development of alcohol are not directly responsible for significant changes in the shape of titration curves. This was proven by adding specific amounts of pure sucrose, dextrose and alcohol before titrating the musts.

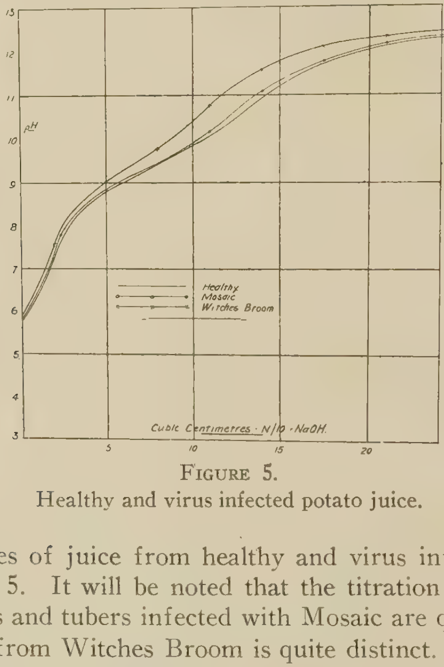

FIGURE 5.
Healthy and virus infected potato juice.

Titration curves of juice from healthy and virus infected potato tubers are given in figure 5. It will be noted that the titration curves of the juice from healthy tubers and tubers infected with Mosaic are quite similar, but the curve of the juice from Witches Broom is quite distinct. A similar relationship was found by Jones (*2*) who studied the specific resistance of juice from healthy tubers and those with Mosaic and Witches Broom. The specific resistance was slightly higher in Mosaic, but very significantly higher in the juice from tubers infected with Witches Broom.

Titration curves of apple and plum juice are given in figure 6. These juices were used as culture media in the laboratory. As one would expect, the apple and pear juice curves are more similar than the plum in shape.

Titration curves are given in figure 7, of the juice expressed from three varieties of grapes, Campbell's Early, grown at Saanichton, and Concord and Niagara grown in the Okanagan, B.C., in 1930. The marked difference in the total acid is the striking characteristic.

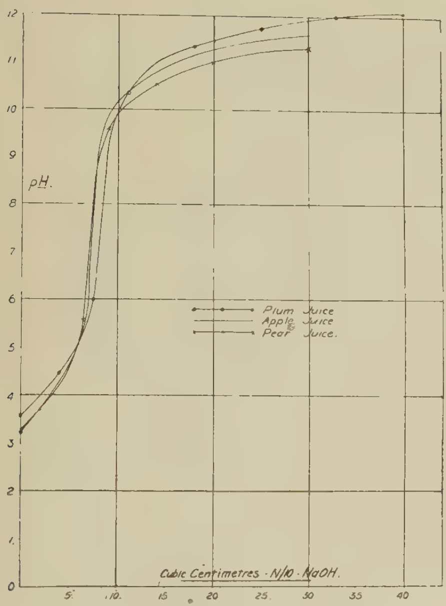

FIGURE 6.
Apple, Pear and Plum juice.

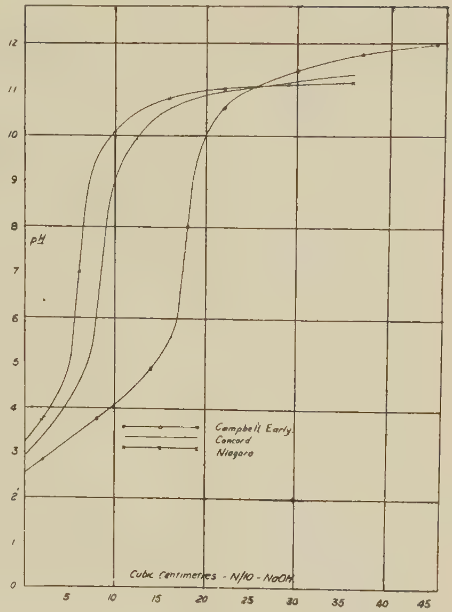

FIGURE 7.
Grape juice.

SUMMARY

Titration curves of fruit and vegetable juices and culture media indicate their possible significance in fermentation and plant disease studies. For example the total acid of loganberry juice decreases progressively with the maturation of the fruit but this is not accompanied by a progressive increase of the initial pH values. Fermentation by a wine yeast brings about qualitative as well as quantitative changes in loganberry must.

A distinct difference occurs in the shape of the titration curve of juice from tubers infected with Witches Broom compared with the juice from healthy tubers and those infected with Mosaic.

The shapes of the titration curves of apple and pear juice are more similar than that of the plum, and those of three distinct grape varieties reveal marked differences in total acid.

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LA CLASSIFICATION DES SOLS FORESTIERS EN FONCTION DE L'ECONOMIE RURALE.

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Mieux vaudrait souvent laisser en dépaissance les terres pauvres et écartées, et consacrer un surcroit de travail aux terres riches et bien situées.—Paul Leroy-Beaulieu.

L'expansion extraordinaire du domaine agricole survenue au Canada depuis les trois dernières décades par la colonisation des plaines de l'Ouest, les développements importants dans la technique agricole pour améliorer et au besoin transformer nos systèmes de culture, en vue d'augmenter la production, la concurrence effrénée que nous livrent les pays étrangers dans le domaine de la production agricole, sont des faits d'une importance capitale par suite des conséquences qu'ils peuvent avoir sur l'économie rurale dans les provinces de l'Est, notamment dans la province de Québec.

Tout progrès technique, soit dans l'agriculture, soit dans l'industrie, tend à réduire les frais de production. De même que la rareté des produits provoque la hausse des prix, leur abondance excessive les abaisse, et cette décroissance de la valeur des produits, ceux du sol entr'autres, puisqu'il ne sera question ici que des choses qui regardent l'agriculture, tend à réduire la rente de la terre et à restreindre l'étendue des cultures. Cette restriction de la culture peut s'appliquer aux denrées, dont le produit de vente est inférieur aux frais de production, et à certaines mauvaises terres incapables, même avec de bons soins, de rémunérer suffisamment leurs propriétaires. De ce phénomène économique il résulte une diminution de certaines productions et un délaissement des terres les moins bonnes.

Le phénomène de la désertion des campagnes, pouvant trouver sa cause première dans un classement inadéquat de certains sols forestiers, est non seulement l'objet d'une attention toute spéciale de notre part, mais il constitue le thème principal de cette conférence; il est le pôle autour duquel convergent toutes les considérations exposées dans cette brève étude.

La stabilité des prix des denrées ou leur progression lente, en face d'une hausse rapide et disproportionnelle des prix des produits industriels et des salaires, peut provoquer l'abandon de nombreuses terres. Inversement une dépression dans l'industrie, s'accompagnant d'une baisse dans les salaires, peut amener, en dégonflant les centres industriels, où le travail est moins abondant et moins rémunéré, un retour à la terre, ou du moins porter certains terriens à demeurer sur leurs terres, si médiocres soient-elles.

Si le terrien aussi bien que le prolétaire cherchent à obtenir la plus grande rémunération possible pour leur travail, il va de soi que cette considération peut les conduire dans les milieux où le travail est le mieux rémunéré. L'on sait que de grands développements industriels attirent beaucoup de monde et il n'est pas douteux qu'ils induisent un grand nombre de ruraux à délaisser des biens, détestables à leur point de vue, parce que le travail qu'ils consacrent à les cultiver n'est pas suffisamment rémunéré.

L'étude du phénomène de la migration des ruraux vers les villes nous induit à observer certains faits révélateurs des causes de cette migration. Sans vouloir analyser cette question à fond, nous croyons devoir diviser en trois classes ces migrateurs des campagnes: les fils de cultivateurs qui ne peuvent ou ne veulent défricher ou cultiver la terre, les prolétaires résidant généralement dans les villages, puis en troisième lieu, les familles établies sur de mauvaises terres. Le défrichement et la culture de terres ingrates, en ne rémunérant que très faiblement un travail ardu, prolongé et constant, tendent à dégoûter un terrien et ses fils, s'il en a, du défrichement et de la culture, les obligent à se faire assez souvent prolétaires et les préparent lentement à cet état, avec comme conséquence l'abandon possible de la terre, la migration vers le village et peut-être la ville.

L'agriculture dans Québec

Dans une conférence prononcée à St-Hyacinthe en 1928, aux Semaines Sociales du Canada, le Dr. Louis Philippe Roy, directeur des services au Ministère de l'Agriculture de Québec, disait: "La production spécialisée des ceréales dans les provinces de l'Ouest, celle des légumes et des fruits dans l'Ontario et la Colombie-Anglaise, obligent aujourd'hui, pour des raisons économiques, nos cultivateurs à se limiter à quatre ou cinq productions qu'il leur faut développer davantage et auxquelles ils doivent pratiquement se limiter." Quatre ou cinq variétés de produits agricoles, seulement, qu'il nous est posible de placer avantageusement sur le marché! Et M. Roy continue: "Or, ce développement nécessaire des productions, qui, par rapport à notre sol et à notre situation géographique, nous permet de soutenir la concurrence, réclame des instruments plus puissants et nous oblige à avoir recours à des méthodes culturales meilleures." L'Ouest nous a enlevé la culture des céréales, l'Ontario et la Colombie-Anglaise, celle des fruits et des légumes, en sorte qu'il ne reste pour les cultivateurs de la Province de Québec que la culture de quatre ou cinq productions agricoles ayant quelque importance.

M. Charles Gagné, professeur d'Economie rurale au Collège d'Agriculture de Ste-Anne de la Pocatière, dans sa conférence qu'il prononçait également à la Semaine Sociale de St-Hyacinthe, précisant davantage, faisait remarquer "que depuis 1850, la culture du blé dans le Québec a contamment diminué en étendue et que la soudaine mise en culture des millions d'acres de terre de l'Ouest canadien a certainement contribué à rendre plus dure la concurrence pour nos cultivateurs de l'Est." Puis il fait cette déclaration qui sonne comme un avertissement: "La classification de nos sols est encore à commencer. Et pourtant, que d'erreurs en colonisation et en agriculture ce travail bien conduit depuis 1850 nous eut épargnées dans cette province! On ne saura jamais le nombre de Canadiens partis pour les Etats-Unis, depuis soixante-quinze ans, parce que leurs terres ne valaient rien pour la culture. Quand on songe à la somme d'énergie, de privations et de sacrifices qu'il fallait, il y a trente ans, pour défricher un lot, on ne se lasse pas de déplorer ce manque de classification des sols, qui nous eût permis d'assigner à l'agriculture et à l'industrie forestière leurs domaines respectifs. La classification des sols ne servirait pas seulement à orienter nos mouvements de colonisation, mais elle faciliterait énormément le travail quotidien de nos agronomes."

Par la voix de réprésentants autorisés, les préposés à l'enseignement agricole en cette province nous représentent que le champ de notre produc-

tion agricole est étroit et que beaucoup de terres spécifiquement concédées pour fins de culture ont été abandonnées par leurs propriétaires, dont un nombre incalculable est parti pour les Etats-Unis.

Il me semble que les techniciens agricoles et forestiers de cette province sont tous d'accord pour regretter les erreurs du passé et qu'il leur est possible d'unir leurs efforts pour en arriver à établir, si la chose peut se faire, un critérium de bonté des terres, en tenant compte de l'état et de la nature de notre production agricole, des conditions d'écoulement de nos denrées, de notre situation par rapport aux autres producteurs, de la concurrence qui nous est faite, soit au pays, soit à l'étranger, et de l'étendue et de la situation de nos meilleures terres arables canadiennes.

Coup d'oeil sur les conditions de la production agricole.—

Les causes qui tendent à réduire les bénéfices de nos exploitations agricoles son nombreuses et profondes. Nous vivons d'abord dans un pays où le coût de la vie est très élevé comparativement à d'autres contrées, où les salaires sont plus bas, le vêtement, le logis, etc., meilleur marché. L'avantage qu'ont ces pays de se procurer à meilleur compte que nous les choses nécessaires à la vie leur permet de mettre sur le marché des denrées dont les frais de production n'égalent pas, pour des produits similaires, ceux de nos exploitations agricoles.

En plus de faire face à la concurrence extérieure, nous avons à lutter contre celle que nous livre l'Ouest canadien avec ses immenses plaines argileuses, qui peuvent être affectées, non seulement à la culture du blé, mais à celle de n'importe quelles denrées et produire ces denrées à bien meilleur compte que ne le peuvent faire un grand nombre de fermes de la province de Québec.

D'autre part, la technique agricole, dont les progrès s'accentuent de jour en jour, chez nous aussi bien que dans beaucoup de pays, a pour objectif d'augmenter la production des terres et la qualité des produits, tout en cherchant à réduire les frais de production, par l'emploi de machines appropriées.

Tous ces phénomènes économiques n'auront-ils pas pour effet de rendre impossible la culture des terres médiocres dans la Province de Québec et ne seront-ils pas la cause de nombreuses désertions? J'estime que les terres fertiles seulement ou les terres avantageusement situées pour l'écoulement des produits ou encore celles qui se prêtent à certaines cultures spéciales pourront être cultivées profitablement dans la Province de Québec.

Toutes les autres terres, auxquelles il faut consacrer, pour les faire produire, une certaine somme de capitaux, seront nécessairement abandonnées, s'il n'est pas posssible, soit par suite de l'infériorité de leur sol ou de leur mauvaise situation ou d'autres inconvénients physiques, de retirer, en les cultivant, un intérêt, fût-il très minime, de ces capitaux. Ces terres, si elles ne peuvent servir même pour le pâturage, seront abandonnées à l'oeuvre de la nature, et l'on pourra dire d'elles qu'elles constituaient des terrains

La rente de la terre.

Cette question de la rente de la terre est une de celles qui ont été le plus débattues et le plus controversées par les économistes du siècle dernier et je crois devoir en parler ici, pour en tirer des conclusions qui pourront peut-

être jeter un peu de clarté sur ce problème difficile et compliqué de la classification de nos sols forestiers. Cette théorie de la rente est due au célèbre économiste anglais Ricardo. "Quelle qu'ait été l'inégalité des frais de production, le prix d'une marchandise ou d'une denrée est le même à un même moment et sur un même marché. Toutes les terres n'ont pas naturellement la même force productive, ni la même situation plus ou moins avantageuse par rapport au marché, et enfin, au delà d'un certain degré de capitaux employés à la culture," (nous pourrions ajouter au défrichement) "il advient que l'emploi d'un surcroit de capitaux produit souvent un rendement proportionnellement moindre que ne le faisaient les capitaux antérieurs." (1).

"La rente," dit Leroy-Beaulieu, "représente simplement l'avantage natu- "rel de fertilité ou l'avantage social de situation qu'ont certaines terres "relativement aux plus pauvres terres ou aux plus mal situées que la néces- "sité d'approvisionner suffisamment le marché force à mettre en culture et "que le prix des denrées induit à le faire." (2)

Laissons Leroy-Beaulieu nous donner un exemple de la façon dont nait et se développe la rente de la terre. "Quand," dit-il, "dans une pays tout "le sol n'est pas occupé et que la population n'est pas très dense, les hommes "ont à proximité une grande quantité de terres disponibles de bonne qualité." (Exemple: l'Ouest canadien).

"Les agriculteurs les metten en valeur, mais au bout d'une certain temps "la population augmente, toutes les terres de bonne qualité, toutes celles, "du moins, qui sont près du marché, ont été appropriées. Elles ne suffisent "pas à l'approvisionnement de la population. Les agriculteurs qui survien- "nent ne peuvent plus se procurer que des terres de qualité médiocre, qui don- "nent un moindre rendement que les précédentes, ou bien des terres plus "éloignées du marché et qui exigent plus de frais pour le transport des pro- "duits."

"La population croissante a exigé un approvisionnement plus considéra- "ble; les nouveaux agriculteurs ne s'adressent pas aux premiers qui ont pris "les terres les meilleures et les mieux situées; ils vont tous mettre en culture "des terres de fertilité naturelle inférieure ou des terres moins bien situées; "le blé, si nous considérons particulièrement ce produit, leur coûte plus cher "à produire ou à transporter qu'aux propriétaires des premières terres; "or, comme il faut que le prix, pour que la production se maintienne, "indemnise le producteur de tous ses frais, et que, d'ailleurs, les récoltes de "ces terres moins fertiles ou plus éloignées sont indispensables à l'appro- "visionnement des habitants, le prix du blé haussera; il haussera dans une "proportion équivalant au renchérissement des frais de production ou de "transport qu'ont à subir les propriétaires des terres les moins fertiles et "les plus distantes. Comme, d'autre part, il ne peut y avoir sur le marché "et au même moment qu'un même prix pour un objet d'une même nature "et d'une même qualité, ce n'est pas seulement le blé produit par les terres "médiocres et les terres éloignées qui se vendra plus cher que le blé ne se "vendait auparavant, c'est aussi le blé produit par les terres les meilleures "et les mieux situées. Ainsi, les propriétaires de celles-ci percevraient, "grâce à cette hausse, dûe à la cause qui vient d'être dite, un supplément de

(1) Economie Politique, page 703, Vol. 1. Paul Leroy-Beaulieu.
(2) Economie Politique, page 710, Vol. 1. Paul Leroy-Beaulieu.

"rémunération, lequel serait la rente au sens scientifique du mot. Ce supplé-"ment de rémunération durerait autant que ces circonstances." (3)

La rente repose sur l'inégalité des frais de production des bonnes terres par rapport aux moins bonnes; elle est "la différence entre la productivité "des terres plus fertiles relativement aux terres moins fertiles." (4)

Ricardo et surtout ses disciples croyaient que la rente de la terre devait s'accroître de plus en plus et que "la terre imposerait à une production crois-"sante des difficultés croissantes." (5)

Or les faits se sont chargés, du moins dans une certaine mesure, de démentir les conclusions que l'on avait tirées de cette loi, à savoir que la rente de la terre a une tendance à s'accroitre constamment.

L'écrivain anglais Porter fait mention d'une grande hausse de la rente de 1800 à 1815, puis d'un recul considérable de 1815 à 1840. Une nouvelle hausse se manifesta vers 1850, suivie d'une dépression à partir de 1875 qui durait encore en 1910. (6). Nous savons que la rente de la terre subit une nouvelle et courte hausse en 1914, qui culmina en 1920 pour redescendre considérablement, remonter légèrement et redescendre en 1930.

Que la rente de la terre ait une tendance à s'accroître en dépit des progrès de la science agricole et du défrichement de terres nouvelles dans les pays neufs, la chose est possible, mais cet accroissement s'accompagne d'une hausse presque équivalente dans les prix des choses nécessaires à la vie; en sorte que les propriétaires des moins bonnes terres se trouvent, pour l'achat de ces matières, dans la même situation que les propriétaires de terres meilleures; d'où il suit que, dans le cas de la hausse comme de la baisse de la rente, la situation des propriétaires de mauvaises terres est toujours critique.

L'Ouest, notre grand concurrent—

Le Canada est un pays encore jeune, et ses possibilités agricoles sont considérables. On l'a surnommé avec raison l'empire des bois et des blés, les bois étant dans l'Est et les blés dans l'Ouest. Le sol étant facile et peu coûteux à défricher là-bas et d'autres part difficile et coûteux à mettre en culture ici, il s'en suit que les terres de l'Ouest, pour la bonne raison qu'elles requièrent, pour produire, beaucoup moins de capitaux que les terres de l'Est, peuvent être vendues beaucoup meilleur marché et être mises en état de productcion beaucoup plus rapidement que ne peuvent l'être les terres de l'Est.

Nous sommes donc fondés à prétendre, toutes choses étant égales d'ailleurs, qu'il y a rente pour un beaucoup plus grand nombre de terres dans l'Ouest que dans l'Est, parce que les capitaux qui ont été incorporés à ces terres faciles à défricher sont de beaucoup inférieurs à ceux auxquels il a fallu faire appel pour défricher nos terres de l'Est; en sorte qu'il suffit pour rémunérer ces capitaux de détacher des profits de la culture une partie très infime.

Les avantages des terres de l'Ouest sur celles de l'Est résident seulement dans la rapidité et la facilité qu'il y a de les mettre en culture; les

(3) Opus cité page 711, P. Leroy-Beaulieu.
(4) Opus cité page 722, P. Leroy-Beaulieu.
(5) Opus cité page 732. P. Leroy-Beaulieu.
(6) Opus cité page 746. P. Leroy-Beaulieu.

frais d'entretien du cheptel et de l'outillage, ainsi que les marchés, étant à peu près les mêmes dans les deux cas. Il reste cependant que la terre à culture doit être bon marché dans l'Ouest, parce qu'il existe là une grande quantité de terres disponibles que les nouveaux venus ou les nationaux peuvent aller mettre en culture avec peu de frais, au lieu d'acheter des terres défrichées.

Par ailleurs, s'il arrive que la culture d'une denrée, celle du blé par exemple, ne rémunère pas suffisamment le fermier de l'Ouest, par suite de la concurrence que lui font les producteurs étrangers, il lui est facile de changer sa production et de se livrer, soit à l'industrie laitière, soit à l'élevage, sur une grande échelle, du porc, des bovins, des moutons, des vaches laitières, puis d'envahir nos marchés de l'Est de beurre, de laine et de viande, car la Nouvelle-Zélande aussi bien que l'Australie n'ont pas à croire que l'Ouest, une fois outillé pour cette fin, ne puisse leur faire une concurrence fort dommageable.

Nous percevons clairement, d'après ces aperçus sommaires, la nécessité qu'il y a pour nous d'avoir des terres capables de soutenir avantageusement la concurrence des terres de l'Ouest; d'ou il suit que notre devoir est de ne concéder à nos colons que les meilleures terres. Lorsque toutes les bonnes terres du pays auront été concédées et que la demande pour les denrées nous induira à le faire, nous pourrons alors concéder des terres moins bonnes, exigeant, pour être mises en état de culture et de production, de plus forts capitaux.

La classification de nos sols forestiers est à la base de notre prospérité agricole.

Des considérations que nous venons d'exposer, il découle que la situation sera dure pour l'agriculteur dont le fonds de terre sera d'une culture malaisée, entrainant des frais de production trop élevés.

Certains propriétaires, c'est surtout le cas des paroisses naissantes, peuvent être temporairement avantagés par certaines circonstances passagères: telles la vente des bois, dont leurs terres sont pourvues, ou encore la rémunération qu'ils reçoivent pour du travail accompli dans la construction des voies de communication ou dans l'exploitation des forêts, ou pour d'autres menus travaux d'occurrence journalière dans une colonie naissante.

Or, l'on sait que les forêts privées sont, du moins pour les fins du commerce, rapidement épuisées; il en est de même du travail qu'occasionne la construction des chemins. Par ailleurs, l'exploitation des forêts régionales, depuis surtout l'absorption des petites sociétés forestières par les grandes, ne se fait plus que d'une manière très intermittente.

Les travaux ruraux, autres que ceux de la culture du sol, ayant tendance à décroître dans les colonies, un temps vient où la main d'oeuvre, en se faisant trop abondante, oblige un certain nombre d'hommes à aller travailler ailleurs. Pour la même raison les fermes qui ne sont pas suffisament douées pour faire vivre leurs propriétaires sont abondonnées et, quand elles peuvent trouver un acquéreur, vendues généralement à vil prix.

La désertion de telles fermes s'est manifestée dans plusieurs parties de la province de Québec; on en voit encore les traces dans les cantons de l'Est, la région du Nord de Montréal, Montmagny, Bellechasse et autres endroits. Ces abandons ne sont un secret pour personne.

"Nous exploitons, dit le Dr. Louis Philippe Roy, de grandes étendues "d'un sol qui n'aurait jamais dû être ravi au domaine forestier." Dans la revue forestière, La Forêt et la Ferme, d'Avril 1929, M. Avila Bédard, directeur de l'Ecole d'Arpentage et de Génie Forestier, écrivait: "Pourquoi, "du reste, cette obstination à vouloir, sans nécessité, lutter contre l'ordre "établi par la nature? Pourquoi persister à vouloir créer sur des terres dont "la pauvreté et la structure défient et découragent l'énergie du laboureur, des "peuplements ephémères de misère?" Ce sont là des admissions et des adhésions.

Déjà quelques voix s'élèvent pour souligner le fait que les possibilités agricoles de la Province de Québec ne sont pas grandes, "Une première "constatation," écrit le professeur Nagant (7), "qui se dégage de l'examen "sommaire des trois provinces géologiques qui apparaissent si nettement sur "une carte du Québec, c'est que, comparativement à son immense étendue, "elle ne possède qu'une faible proportion de terres exploitées ou exploitables "par l'agriculture."

Au congrès de Colonisation de 1923, M. G.-C. Piché, Chef du Service forestier, exprimait une opinion partiellement identique: "Je ne partage "pas", disait-il, "l'opinion de ceux qui prétendent que la province de Québec "est un pays essentiellement agricole. Je soutiens plutôt que c'est un pays "essentiellement forestier". Si j'avais à exprimer mon opinion, je vous dirais que j'incline à croire de plus en plus que la province de Québec, par la force des choses, sera, avant tout, industrielle.

L'abondance de ses pouvoirs hydrauliques, leur accès facile, le bon esprit de sa population, les énormes capitaux disponibles dans le monde, tous ces facteurs joints à la rapidité avec laquelle se développe l'industrie, comparativement aux progrès de la colonisation, qui sont plutôt lents, ne peuvent que produire un développement industriel peut-être modéré, peut-être rapide, mais constant et considérable.

J'ai dit tout à l'heure que notre pays était encore jeune, et personne ne le niera. Il est de plus doué de ressources naturelles riches et abondantes. L'exploitation de ces richesses, aux endroits où elle marche de pair avec le développement de la colonisation, de l'agriculture et de l'industrie, ne laisse pas à ses débuts de bras disponibles. Mais vient un temps où ces ressources naturelles, les forêts entre autres, se font de plus en plus rares, principalement dans les régions à culture, et ne procurent bientôt plus que quelques journées de travail, prenant ainsi au dépourvu une certaine quantité de travailleurs, dont beaucoup de colons, qui sont obligés de regarder ailleurs pour remplacer ce moyen de subsistance.

On trouve un des exemples les plus frappants de cet état de choses dans la Nouvelle-Angleterre; la Division Expérimentale de l'Université de Cornell publia en 1928, à la suite d'un examen détaillé des conditions de l'agriculture dans l'Etat de New-York, un rapport très élaboré de cet examen.

L'étendue du territoire agricole de l'Etat de New-York, de 23,780,754 acres en 1880, n'était plus que de 19,269,926 en 1925, soit une diminution de plus de 4,500,000 ou de 7,030 milles carrés. De 1880 à 1910, une moyenne de 60,000 acres furent abondonnés annuellement; de 1910 à 1920, 140,000

(7) Conférences par M. H.-M. Nagant, professeur de chimie et de géologie à l'Institut Agricole d'Oka.

acres par année; et de 1920 à 1925, l'abandon est de 270,000 acres annuellement. L'on a attribué cette désertion à la pauvreté du sol, aux accidents du terrain et à l'utilisation de certains espaces pour le développement des villes.

A quelles grandes causes faudrait-il surtout rattacher cette désertion sur une si haute échelle des plus mauvaises terres de l'Etat de New-York? A la colonisation des terres de l'Ouest suivant nous, et aussi à la formidable expansion de l'industrie américaine depuis le dernier demi-siècle. Il en sera de même dans la Province de Québec, aussi bien que dans la Province d'Ontario, n'en doutons pas. La formidable concurrence que livreront sans cesse les agriculteurs de l'Ouest à ceux de l'Est, concurrence que va accentuer encore davantage la baisse des prix du blé, rendra impossible la culture des mauvaises terres dans la Province de Québec.

Est-ce à dire que nous devons mettre un terme à colonisation? Non. Voyons plutôt à placer nos colons sur des terres où la technique agricole aura des chances d'exécuter son travail bienfaisant. Si la couronne concède des terres de mauvaise qualité, les gouvernants pourront en recevoir le blâme, mais les techniciens, auteurs du classement des sols foretiers, en porteront la plus grande part de responsabilité.

Société D'Expertise Agricole

Under the name of the "Société d'Expertise Agricole" three members of the C.S.T.A. in Montreal have formed an organization to give service to industrial concerns seeking contact with the agricultural interests of Quebec and to also make contacts in the opposite direction. It is at once obvious that there is a field for work in translation such as has already been done by Mr. Robert Raynauld in preparing the French edition of "Field and Farm Yard", published by the Imperial Oil Company. Other functions which the directors expect to perform are farm planning and soil analysis; advice on farm bookkeeping and farm management; valuation of land and chattels in view of expropriation for highways, railways, etc.; technical advice to municipalities in connection with drainage, aqueducts, electrification, sanitation, engineering; landscape gardening; and translation and publicity in both French and English. The experts who are offering their services are Mr. Robert Raynauld, M.S.A., Managing Director, Mr. P. Vezina, L.S.A., Consulting Agronomist and Mr. A. Lamontagne, I. C., Consulting Engineer. It is to be hoped that results will justify the vision and initiative of these gentlemen.

CONCERNING THE C.S.T.A.

The April Issue of Scientific Agriculture

Attention is directed to the article on the economic situation by Dr. G. F. Warren, Professor of Agricultural Economics and Farm Management at Cornell University. Dr. Warren addressed the C.S.T.A. convention at Wolfville last June but since that time has been so exceedingly busy that he has not been able to prepare his address for publication. Following the Second International Conference of Agricultural Economists which was held at Cornell last year Dr. Warren further emphasized his impressions of the economic situation in a paper delivered to the American Farm Bureau Federation in a meeting at Boston, December 1930. We present this paper which is published for the first time and we also present his paper given at Wolfville on the organization of a Department of Agricultural Economics. The first article deserves not a casual reading, but several hours of study. It should appeal particularly to extension and administration men who come into close contact with the present problems of distribution and marketing. It is quite possible that one of the open lectures at the next convention at Guelph will be on the general economic situation and a clear understanding of the contents of Dr. Warren's paper will assist materially in an appreciation of this lecture.

The lectures given by Dr. L. J. Stadler at the Maritime convention have been prepared recently and the first of these will appear in the May issue under the title of "The Experimental Modification of Heredity in Crop Plants." The second paper, which will appear in the June issue, will complete the series of lectures given at last year's convention.

Dr. Craigie Wins Important Prize

Dr. J. H. Craigie, Officer in Charge of the Dominion Rust Research Laboratory, Winnipeg, Man., who is at present studying at Cambridge, England, has been awarded the Eriksson Prize. This prize was offered for the best memoir giving an account of new and original work on the subject, "Investigations on Rust (Uredineae) Diseases of Cereals (Wheat, Oats, Barley or Rye)." The value of the prize was 1,000 Swedish Crowns. The award was announced at the Cleveland meetings of the American Phytopathological Society, held Dec. 30, 1930, to Jan. 1, 1931.

In 1927 Dr. Craigie reported that *Puccinia graminis* and *P. Helianthi* were hetrothallic and later the same year he announced the discovery of the function of the pycnia of the rust fungi. This discovery gave some foundation to the hypothesis that physiologic forms of stem rust may arise in nature by hybridization. What was indeed more important, was that he demonstrated a method by which the hypothesis might be tested. Drs. Margaret Newton and T. Johnson, of the Rust Research Laboratory and Dr. Stakman and his colleagues at the University of Minnesota, presented evidence, using Craigie's method, that physiologic forms of stem rust might arise freely in nature by hybridization. The original papers on these findings were published in *Scientific Agriculture* last July.

Visits to Locals

The Dominion President and General Secretary visited the Niagara branch of the C.S.T.A. on February 25th. An interesting meeting was held

in Hamilton at the time of the Fruit Growers Convention. The meeting took the form of a bowling tournament with the Toronto branch, followed by a dinner and a discussion of the affairs of the Society.

On March 24th a visit was made to the Macdonald College local when a dinner and discussion was held, following which several of the members adjourned for a bridge party. During the day the President and Secretary discussed Society matters with several of the Macdonald College staff. A good delegation from Montreal attended the dinner.

On the following day the General Secretary joined with the Montreal members in a luncheon at Krausmans' restaurant. Here the matter of a separate Montreal City local was discussed and plans were made to lay this before the members of the other locals affected and before the Directors of the Society. The general tendency at the present time seems to be to separate the commercial and administrative centres from the university centres in order that the two may develop the particular type of programme which appeals to them most. It is felt that this is not a weakening of strength, but rather the natural development of diversified interests in a Society such as we have. A similar movement is under way at Sherbrooke to give the members of that district an opportunity of meeting together as a local. At present they are affiliated with the locals at some distance from their natural centre.

Imperial Oil Publishes Book on Farm Management

We have recently received a copy of the third of the Imperial Oil books for farmers. The two previous ones, "Field and Farmyard" and "Weed Control", have been accepted with enthusiasm by farmers, over 80,000 copies of each having been distributed. The book offered this year is again prepared by the Hon. Duncan Marshall, formerly Minister of Agriculture for the Province of Alberta. While admitting his success in the two previous volumes, one might be pardoned for doubting the advisability of attempting to write a book on farm management compiled from observations made on visits to a comparatively small number of farms, a comparatively small number because we commonly think of farm management surveys in terms of a large number of units statistically analysed to avoid the influence of special cases. Happily, however, one's fears are not well grounded and Mr. Marshall's book, while purposely avoiding a technical presentation of the subject, pays sufficient attention to principles that have been upheld by technical study to be thoroughly sound and reliable. As a matter of fact, there is more good, plain common sense for farmers in the new Imperial Oil book on Farm Management than in any other book or article we have seen on the subject.

Copies are available free from the Imperial Oil Company, Limited, and members of the C.S.T.A. who desire a copy for their personal use are requested to forward the clipping from the advertisement on the back cover of this issue.

New Members

The following applications for regular membership have been received since March 1, 1931:

Brown, A. R. (Saskatchewan, 1922, B.S.A.), Regina, Sask.
Latta, F. C. (Saskatchewan, 1926, B.S.A.), Regina, Sask.
Nelson, N. T. (Wisconsin, 1919, B.S.A.), Ottawa, Ont.

Notes and News

B. H. Wilson (Alberta '27) has resigned from his position at the Dominion Experimental Farm, Indian Head and has moved to Edmonton to spend some time in regaining his health. His address is 9850—102nd St., Edmonton, Alta.

K. W. Neatby (Saskatchewan '24) has returned from his work in the Division of Agronomy and Plant Genetics at the Minnesota College of Agriculture, and is now at the Dominion Rust Research Laboratory, Winnipeg, Man.

S. E. Todd (Toronto '10) of the Industrial and Development Council of Canadian Meat Packers, Ltd., informs us that the address of this organization has been changed to Room 406, 200 Bay St., Toronto.

W. H. Hill (Toronto '16), Analyst in Charge of the Food and Drugs Division, Department of National Health, has changed his laboratory to 506-516 British Columbia Mining Building, 402 Pender St. W., Vancouver, B.C.

E. A. Atwell (McGill '23) has changed his address to 52 Willard Ave., Ottawa, Ont.

P. H. Granger (Montreal '28) Agronome for Drummond County, has changed his address to Box 247, Drummondville, P.Q.

G. LeLacheur (McGill '13) has been promoted to the position of District Seed and Feed Inspector for District No. 1, retroactive to November 31, 1930. Mr. LeLacheur has spent a great deal of time and energy in establishing the Dominion Seed Laboratory at Sackville, N.B., and his many friends in the C.S.T.A. are pleased to learn of his official appointment.

K. F. Moffatt (British Columbia '28) is now on the Sales staff of Canadian Industries Limited at New Westminster, B.C.

F. H. Peto (Manitoba '28) has concluded work for his master of science degree in the University of Alberta, and is now pursuing further cytological research at the Welsh Plant Breeding Station. His address is Welsh Plant Breeding Station, Agricultural Building, Aberystwyth, Wales.

W. B. H. Marshall (McGill '28) is acting as senior Fruit and Vegetable Inspector at Quebec City. Mr. Marshall was formerly junior inspector in Montreal.

H. L. Steves (British Columbia '24), Holstein-Friesian Association Fieldman for Western Canada, has moved from Steveston, B.C., to 25 Lorscott Mansions, Regina, Sask., from which point he will carry on the promotion work of the association for the Western Provinces.

Damase Limoges (Montreal '25), formerly Assistant Agronome for Terrebonne Co., P.Q., is now Sheep and Swine Inspector for the Quebec Government and is located at Ste. Thérèse de Blainville, Terrebonne Co., P.Q.

G. C. Warren (Toronto '27) expects to return to duty at the Charlottetown Experimental Farm shortly. For the past few months he has been at Acadia University, Wolfville, N.S.

H. D. Mitchell (McGill '15), formerly with Jamesway, Limited, at London, Ontario, has been appointed Field Husbandman at the Central Experimental Farm, Ottawa, Ont.

R. M. Wilson (Manitoba '24) has been transferred from the Experimental Farm at Morden to the Experimental Farm at Indian Head, Sask.